UNIVERSITY OF CAPE TOWN

"Injury Prone Areas"

Repeat Presentations for Injuries in Childhood

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Part 0: Preamble

1) Plagiarism Declaration

I, Shrikant Maurice Peters, do hereby declare that the work on which this dissertation is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Shrikant Maurice Peters

Date: 11th October 2018

2) Dedication

AD MAJORAM DEI GLORIAM

I dedicate this work to the love, faith and support of my wife, Maria, the courage and strength of my twin brother, Shriyan, the wisdom and guidance of my parents, Padmini & Paul, the loving warmth of my dog, Maya, and to my Lord and God for blessing me with all of them.

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4) Abstract

Background: Injury remains a leading cause of childhood morbidity and mortality in the developing world. Probability of injury occurrence is influenced by agent, host and environmental factors. Studies of repeat injuries in childhood thus provide insight into factors in the epidemiological triad predisposing children to injury.

Objectives: The study objectives were to determine the proportion of children and the factors associated with repeat presentations to Red Cross War Memorial Children's Hospital Trauma Unit (RCWMCH TU) for all non-transport related injuries in childhood.

Methods: This was a retrospective cohort study using data from RCWMCH TU. We included children aged 0-10 years with first presentation from January 1997 to June 2013, and followed up until the earliest of age 13 years or June 2016. We assessed individual and population-level factors associated with repeat injury using multilevel Poisson regression. Child Dependency Ratios were derived from the 2011 national census.

Results: Between 1997 and 2013, 72 490 children under 10 years of age (59% male) presented to RCWMCH TU for the first time with injuries. After the initial injury, 9 417 (13%) presented with a repeat injury by 2016 and before age 13 years. After adjusting for health Sub-District, distance from RCWMCH TU and age at first presentation, factors associated with reduced repeat presentation were: injury identified as due to abuse (adjusted incidence rate ratio [aIRR] 0.6; 95% confidence interval [CI]: 0.4 – 0.7), fluid burn (aIRR 0.6; 95% CI: 0.6 – 0.7), foreign body ingestion (aIRR 0.7; 95% CI: 0.7 – 0.9), moderate and severe (vs minor) initial injury (aIRR 0.9; 95% CI: 0.8 – 0.9) and (aIRR 0.7; 95% CI: 0.6 – 0.8 respectively), whilst boys were more likely to have repeat injury presentations (aIRR 1.4; 95% CI: 1.4 – 1.5).

Conclusion: Repeat presentations constituted a substantial proportion of disease burden. Factors associated with repeat presentations were identified, strengthening the argument that injuries arise due to sustained exposure to host, agent and environmental risk factors. While it is reassuring that children with initial injuries due to abuse and severe initial injuries are less likely to present again, injury prevention education should not neglect patients with minor and unintentional injuries. The findings of this study suggest that post-injury health promotion activities should not exclude patients who present with minor injuries, and that targeted education and further research is indicated for specific injuries, including those due to non-height falls and injuries sustained whilst playing sport.

5) Contents

Part A: Protocol

“Injury-Prone Areas”
Repeat Presentations for Injuries in Childhood

A thesis protocol written in partial fulfilment towards a Masters of Medicine (Public Health) Degree

By:

Dr. Shrikant M. Peters

Health Impact Assessment | University of Cape Town

Western Cape Government: Health

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Abbreviations

HICs	High Income Countries
II	Intentional Injury
IMR	Infant Mortality Rate
LMICs	Low Middle Income Country
UI	Unintentional Injury
UNICEF	United Nations International Children's Emergency Fund
NMR	Neonatal Mortality Rate
NIMS	National Infant Mortality Survey
RCWMCH	Red Cross War Memorial Children's Hospital
RI	Repeat Injury
WHO	World Health Organization

1. Purpose of the Study

The purpose of this study shall be to investigate the frequency and factors associated with Repeat Injuries in Childhood (RIC) which result in consecutive presentations to the Red Cross War Memorial Children's Hospital Trauma Unit (RCWMCH TU). This data will inform secondary health promotion efforts at the hospital with regard to predictable and preventable repeat injury events.

1.1. Aim

The aim of this study will be to determine the rate of repeat presentations for injuries in childhood and the factors associated with repeat presentations at RCWMCH TU.

1.2. The Primary Objectives of this study shall be:

- To measure the general incidence rate of Repeat Injuries in Childhood (RIC)
- To measure the specific incidence rate of Repeat Injuries in Childhood (by Aetiology)
- To measure the rate of Repeat Injuries in children first presenting with Unintentional Injury
- To measure the rate of Repeat Injuries in children first presenting with an Intentional Injury

1.3. The Secondary Objectives of the study shall be:

- To determine whether RIC are associated with demographic factors
- To determine whether RIC are associated with geospatial, area and time factors
- To determine whether RIC are associated with certain aetiological categories
- To determine whether RIC are associated with increasing outcome severity

2. Background:

Traumatic injury is a leading cause of disability and mortality in childhood[1]. Despite this, injury prevention efforts are not prioritized in many countries, due to competing disease burdens, especially in Low and Middle Income Countries (LMICs), and the assumption that their occurrences are unforeseeable. This ultimately prejudices the argument that injuries are predictable events, which occur within a framework of identifiable and modifiable risk factors.

ChildSafe South Africa (previously the Child Accident Prevention Foundation of Southern Africa) is a registered NGO and partner of SafeKids Worldwide. It was founded in 1978 under the auspices of the then Head of Paediatric Surgery at the RCWMCH, in Cape Town, South Africa. It was established to counter the growing number of childhood injuries in the country by engaging in research, advocacy and education, centred on increasing awareness and prevention of the leading causes of childhood trauma. In 2014, ChildSafe and its partners established the first 'Safety Demonstration House' in Africa, which is used to educate caregivers of patients admitted with an injury regarding common household hazards with potential to cause serious injury to children[2].

Since 1991, ChildSafe has continuously maintained a database of all children presenting to the Hospital's trauma unit for care post-injury. This data set is one of the few examples of paediatric injury surveillance in LMICs, and has been utilised by many studies which have sought to determine the distribution and determinants of various childhood injuries which predominate within the Cape Town Metropolitan region.

To date, no study has determined an Injury Repeat Rate for the population of children presenting to the RCWMCH TU. Staff working in the unit have given anecdotal evidence of the phenomenon of repeat presentations – stating that a number of children (or their siblings) present to the Unit more than once, for both intentional as well as unintentional injuries[3]. As such, it is currently unknown what proportion of the total headcount at the Unit is due to repeat injuries.

Childhood Injury research has traditionally been divided into Accidental and Non-Accidental Injury (i.e. Abuse), however recent authors have alluded to difficulties in making this distinction practically, as there is growing consensus that both types of injury share certain risk factors, with recommendations that these phenomena be investigated simultaneously[4,5]. Current injury theorists prefer to use the terms Intentional and Unintentional, in order to emphasize the view that injuries should be analysed as the result of a framework of chronological contexts and events, not simply the outcome of random misfortune or chance.

The most commonly used epidemiological framework of injury causation is the Haddon Matrix[6], which provides a comprehensive, chronological approach to classifying and understanding injury aetiology, by identifying factors related to the background Environment, the immediate Agent and the child Victim. This conceptual approach will be utilised in the design and analysis of this study. Repetitive childhood injury has been studied variously, in different demographic contexts, as either a marker of individual accident-proneness or unsafe environments. The existence of a predictable, patterned rate of repeat injury would strengthen the argument that injuries arise due to sustained exposure to events and contextual parameters, and could be used to alert health promotion experts to patients most at risk of experiencing further injuries in future.

2.1.Literature Review:

Introduction

Traumatic injury, defined as 'the physical damage that results when a human body is suddenly subjected to energy in amounts that exceed the threshold of physiological tolerance or is deprived of one or more vital elements'[1], remains one of the leading causes of childhood morbidity and mortality in the world today. Research and advocacy regarding the distribution and determinants of such injuries has traditionally focused on one of two supposedly distinct aetiologies, namely those of 'Accidental' or 'Non-Accidental injuries'. Changes in the conceptualisation of injury causation over time have resulted in these older terms being replaced by the more pointed terms 'Intentional' or 'Unintentional'. The older terms have fallen out of favour in more recent research, as the use of the word 'accidental' belies the fact that injuries are more likely to occur within certain contexts, and are therefore not simply random events, but predictable and preventable outcomes of a model of causation, with a range of individual and group level exposures[7].

The WHO has broadly defined Intentional Injury in children as "child abuse or maltreatment (which) constitutes all forms of physical and/or emotional ill-treatment, sexual abuse, neglect or negligent treatment or commercial or other exploitation, resulting in actual or potential harm to a child's health, survival, development or dignity in the context of a relationship of responsibility, trust or power." Although Intentional Injury of children may be divided into interpersonal violence, self-infliction or collective violence (such as war or genocide) [8], research in the field has historically focused on the behaviour of adults committing acts of interpersonal violence (physical abuse) against children. Conversely, Unintentional Injuries have simply been defined as 'injuries in which there is no identifiable evidence of predetermined intent[9].

Body

Injury Causation Framework

The most widely utilised epidemiological framework of injury causation is the Haddon Matrix[6], which was conceptualised forty years ago, in the context of traffic safety. It allows for the comprehensive description of injury events by making explicit the Agent, Host and Physical-Social Environment factors which potentiate the risk of injury and debilitating outcome.

Table 1: The Haddon Matrix of Injury[6]

Injury Event Phases	Aetiological Dimensions		
	Agent: Object/Substance	Host: Child & Parent	Enviro: Physical-Social
Pre-Event	Water kettle unsecured	Childhood naiveté	Poor lighting
Event	Kettle fall with hot water burn	Lack of supervision	Kettle wiring within reach of floor
Post-Event	Burn injury dressings	Burn First Aid knowledge	Informal area ambulance access

These factors are considered in chronological order; as being pertinent to either pre-event, intra-event or post-event time frames. These then map to primary (pre-event), secondary (event) and tertiary (post-event) prevention activities respectively. The vast differences in disease burden and outcome severity between developed and developing countries, with differing environmental contexts, would appear to corroborate this framework. In addition to the time and aetiology dimensions above, Runyan[10] has more recently proposed the addition of a third 'value criteria' dimension to the Matrix – which may be used to weigh and determine policy interventions based on relative effectiveness, cost, equity and other considerations.

Childhood Injury Statistics

Unintentional Injuries (UI) alone have been estimated to cause the death of over 830 000 children annually[1]. This burden of disease due to UI is unevenly spread globally, with the vast majority of incidence, deaths and long term disability being concentrated in income disparate LMIC economies such as South Africa, where domestic safety protocols and guidelines are either unwritten, unknown or underutilized, living conditions lead to greater hazard exposure, and access to acute trauma care and long term rehabilitation is severely lacking.

The five major categories of unintentional injury affecting children globally include Road Traffic Incidents (RTI's), drowning, burns, poisoning and falls. Rates of injury vary by age group, by gender and by country. New-borns and toddlers are most at risk of domestic hazards, whilst those above the age of four are increasingly exposed to risks outside of the home, such as RTI's and drowning. Injury rates are equivalent for boys and girls until the age of five, at which point boys start to contribute a larger proportion of all unintentional injuries, reaching 86% by the age of 15 years[1].

Intentional Injuries (II) in childhood (including physical, sexual, emotional abuse and neglect) form a far smaller proportion of morbidity and mortality, but have received widespread attention from international organizations such as the World Health Organisation (WHO) and the United Nations International Children's Emergency Fund (UNICEF). The WHO have estimated that in the year 2000, 57 000 childhood deaths under the age of 15 were attributable to homicide, with the very young (age group 0-4) being at greatest risk[11]. Fatality rates differ by gender (boys being at greater risk) and geographical location (with Sub-Saharan Africa recording the highest fatality rates in 0-5 year olds globally) [12].

South African Statistics

South Africa is a markedly income-disparate, upper middle income country. It has a population of approximately 54 million, of which 18.5 million (ie one-third) are children under the age of 18 years old[13]. Of these, 63% of children belong to families living under the upper bound poverty line, concentrated in the rural parts of the country. It is thus not surprising that the country continues to record disappointing childhood mortality statistics, with NMR, IMR and child mortality at 11, 28 and 39 per 1000 live births respectively[14].

Injuries feature prominently across the top causes of mortality in South Africa children, and even when not fatal, contribute towards the prevalence of permanent disability and reduced quality of life[15]. Within the age group 0-5, road traffic incidents, burns, violence and drowning all feature in the top 20 causes of death. As children get older, they spend greater amounts of time outside the home, and thus causes of death external to the household rise in importance – with road traffic incidents, homicides and burns claiming a far greater proportion of lives after the age of 4 years[16]. To date in South Africa, there have been no studies of repeat childhood injuries or 'accident-proneness' performed on local cohort data.

NIMS Data shows that in urban regions, the most common causes of injury-related deaths in those under the age of 14 are road traffic accidents, drowning, burns and gunshots, with large differences in mortality causes between genders, age groups and ethnicities[17]. Numerous, heterogeneous childhood injury studies have taken place in the country. In terms of intentional injury, the Optimus Study, a household and population survey, conducted in 2015, found alarmingly high rates of physical and sexual abuse in South African children. By age 15, one third reported being physically assaulted; one fifth (of girls as well as boys) reported having been sexually assaulted, and one sixth reported some form of neglect[18].

Repeat Injuries in Childhood

The formal investigation of repetitive unintentional childhood injury began in the 1960's, but has been largely confined to hospital-level data from North America or Europe, with studies from the USA heavily predominating. The only developing country to have had similar research is China. As such, repetitive injury has been studied as an outcome largely due to 'accident-proneness', or in other words, largely as a result of risk factors intrinsic to the individual, which predispose to injury. This is to be expected; research in developed countries has tended to focus on individual risk factors – environmental risk in these countries is thought to have been minimized to a greater extent through the use of safety guidelines, policy and legislation, thus environmental risk factors are assumed to play a lesser role in injury causation.

However, in LMICs such as South Africa, markedly differential rates of childhood injury are still observed and have been studied as multifactorial outcomes, related to socioeconomic context **(**family size and structure, living conditions), agent exposure, and individual variation, both in co-morbidities; be they musculo-skeletal, proprioceptive, behavioural or neurocognitive disorders, as well as features of normal childhood; curiosity, impulsivity and excitability, amidst a developing cognitive ability and level of maturity[19]. The complex interplay of these various factors ultimately determines the risk of injury to each individual child.

Repeat injury studies have operationalised accident proneness in study populations via three distinct methods; firstly, as an individual's number of repeat presentations for medical care, secondly as the categorisation of individuals into low, normal or high accident proneness categories, or thirdly as the comparison of single-accident to repeat-accident (accident prone) victims. Even within this narrow view of repeat injuries conducted on the basis of individual "accident proneness" alone, there has been significant difference in the type of studies performed, the age groups studied, and the definition of accident-proneness. The majority of repeat childhood injury studies have investigated rates of presentation to medical facilities following unintentional injury.

A systematic review of repeat injury studies was conducted by Visser *et al.* in 2006, which attempted to collate the various types of injury studies (population, community and facility-based) for meta-analysis. Included were childhood-specific repeat injury studies, as well as studies concerning other age groups. In their meta-analysis, the authors concluded that, within populations of patients either suffering from, or presenting for repeat injuries (as repeat injuries were defined heterogeneously by various studies), there are a sub-group of patients who are at increased risk for repeat injuries, such that they present with greater frequency than that which would be expected due to chance alone[20].

Questions which typically remained unanswered in studies of 'accident-proneness' was the contributory effect of environmental and socio-contextual factors to patient's increased risk of repeat presentation. It was advised that a deeper understanding of the situations in which injuries occur is required to truly determine why certain individuals present recurrently for injury events, to facilitate a more comprehensive understanding of injury causation, and to better inform health promotion efforts designed to alleviate the resultant burden of disease.

Conclusion

Injuries in childhood occur within a complex framework of causation related to the chronological interactions of Agent, Host and Environment; and have traditionally been conceptualised and researched separately as being brought about due to either Intentional or Unintentional aetiologies. However, they share similar factors, including age and gender, family size and structure and socio-economic status.

Studies of repeat injuries have generally tended to focus on hospital-level data, which although able to provide detailed information on patterns of complex and severe injuries, is generally unable to provide detailed contextual information regarding agent and environment-related factors which predispose children to an increased risk of injury. A study of repeat injuries has much potential to: (i) confirm the basic premise of the Haddon Matrix (that injuries are not simply 'once-off', accidental events), (ii) demonstrate the relationship between intentional and unintentional injuries, (iii) predict which injuries are likely to recur, (iv) determine which environments they are most likely to recur in, and (v) predict which children are most likely to present repeatedly for them.

This would be of significant use to an LMIC such as South Africa, in which health promotion efforts are in need of reinforcing, and a shift in mind-set from cure to prevention is required, particularly in the field of childhood injury due to its high burden and debilitating consequences.

3. Methodology

3.1.Study Design

This will be a retrospective cohort study, encompassing descriptive and analytic elements**.** A multilevel analysis will be conducted, by combining individual hospital data with ecological geographic census data. The primary objective will be to determine the general and specific incidence rates of Repeat Injury in Childhood, for children with both intentional and unintentional injuries. Secondary objectives will be to determine whether individual, familial or geospatial risk factors increase risk for Repeat Injuries, and whether Repeat Injuries are associated with severity of presentation and adverse outcomes

3.2.Sample Size

The number of first time presentations to the RCWMCH TU over a 20 year period between the 1st January of 1997 and the 31st December of 2016 are approximately equal to 95 000. As sample size is set, a chi^2 two-independent proportion test of power was ascertained**.** At an alpha level of 0.05 and with a sample size of 95 000, this study is powered to calculate a 2.5% change in a 3:1 ratio differential binary risk factor (take for example; Socio-Economic Status = Low [75%] / Socio-Economic Status = High [25%]) with a 100% level of power, as per the following statistical output table:

Table 2: Sample power for two-sample proportion test for different proportions

Estimated power for a two-sample proportions test
Pearson's chi-squared test
Ho: p2 = p1 versus Ha: p2 != p1

alpha	power	N	N1	N2	nratio	delta	p1	p2
.05	1	95000	23750	71250	3	.025	.125	.15
.05	1	95000	31666	63333	2	.025	.125	.15
.05	1	95000	47500	47500	1	.025	.125	.15

3.3.Characteristics of Study Population

The ChildSafe database maintains records of all childhood trauma victims who have attended the RCWMCH TU since the 1st of January 1991. It is noted that the study population does constitute a vulnerable population – being children under the age of 13 years, who are at risk of either repeated intentional or unintentional injuries.

This population has been chosen for this research, precisely because they are vulnerable to neglect, abuse and accidental injury due to their cognitive, emotional and physical immaturity. Such research would elucidate and enumerate the continued risk posed to victims of abuse, neglect, or accidental injury who present to RCWMCH TU. This research may be utilised to flag children according to risk categories for abuse, which would be beneficial for first presentations in which abuse is not readily evident.

3.4.Inclusion & Exclusion Criteria

- Inclusion Criteria:
    - Patients whose first presentation to the Unit occurs between the 1st of January 1997 and the 31st of December 2013, with follow-up tracking occurring until 31st December 2016.
    - Since RCWMCH TU only sees children <13 years of age, patients must be below the age of 10 years at first presentation, to allow for at least 3 years of follow-up time during which they would have presented to RCWMCH TU if they experienced a second injury.
    - Patients who have suffered from unintentional injuries, intentional injuries, or both (at first or subsequent presentations) of any level of severity, will be included

- Injuries in the following causal categories will be included – Assaults, Burns, Falls, Miscellaneous and Unknown Cause injuries. The top five specific injury categories are falls from height levels, fluid burns, falls from non-height levels, foreign body ingestion and being struck by or against an object or surface.
- Patients must be resident within the Cape Town Metropole at the time of first injury, as children who are not Cape Town residents might not present to RCWMCH TU should they experience a repeat injury.

- Exclusion Criteria:
  - Patients who contribute less than 3 years of study time, including;
    - Patients who are above the age of 10 years at first presentation
    - Patients whose first presentation is less than 3 years before the end of the study period
    - Patients who demise within 3 years of their first presentation
  - Patients who have demised within the trauma unit at first presentation
  - Patients who are resident outside the Cape Town Metropole at the time of injury
  - Patients who present with transport-related injuries; all transport-related injuries, for both first and repeat presentations, were excluded from the analysis.
  - Patients who present with poisoning are not assessed at the RCWMCH TU and were therefore also excluded in this study

4.5 Time Schedule

Data will be accessed from the ChildSafe Database and analysed over a two month period, in conjunction with data from Statistics SA's Census 2011. The proposed timelines are as follows; May – June 2017; ethics protocol submission, June – July 2017; data collection and analysis, and from July – August 2017; report and presentation writing.

4. Data Management

4.1. Data Collection Methods

Data will be utilised from three sources: 1) the ChildSafe Database, 2) Statistics South Africa Census 2011, and 3) Western Cape Provincial Health Data Centre Mortality Database

I) The ChildSafe Database

The ChildSafe Database is a continuous record of paediatric patients (under the age of 13 years) who have presented to RCWMCH trauma unit over a period of 25 years, beginning in January 1991, until the present day. The trauma unit Record tool is completed by administrative and clinical staff at the trauma unit when clerking patients as they present to the unit.

Clinical staff include details as to whether intentional injury is evident or suspected. Completed tools are then sent to ChildSafe for capturing. Captured data is then stored in password-controlled spreadsheets held at ChildSafe. The data is accessed for Research purposes is by a formal application process. Information to be collected from the ChildSafe Database will include anonymous Record ID data; Demographics, Aetiology, Self-Infliction or Abuse; Pattern and Severity of Injury; Area, Date, Time and Location; and Treatment and Method of Disposal from the trauma unit.

Severity of injury is recorded by attending clinicians; once the patient has been assessed and all necessary trauma unit investigations have been completed. The final code is recorded by the doctor on the patient's file, using the following RCWMCH criteria:

1. Minor

Patients with no injury as assessed by the attending trauma unit clinician, or with an injury which requires advice on future prevention only, and who is able to be discharged from the trauma unit directly without requiring admission to the hospital.

2. Moderate

Patients assessed to have moderate injury by the attending trauma unit clinician, which includes all patients with any form of head injury, all patients with wounds which require suturing, all injuries requiring application of plaster of Paris and all patients requiring admission.

3. Severe

Patients who meet the criteria for moderate injury and are additionally considered to have severe, life-threatening injury, as assessed by the attending trauma unit clinicians.

II) The South African Census 2011

Data from the ChildSafe database regarding the child's residential suburb (at first injury) will be matched to publically available South African Census Data from 2011, including Municipal Place, Sub Place, Socio-Economic Status, Household Crowding, Child Dependency Ratio, Type of Housing, as well as the Employment and Educational Status of heads of households.

III) Western Cape Provincial Health Data Centre Mortality Database

The ChildSafe data will also be matched to the Western Cape Provincial Health Data Centre Mortality Database, to identify children who have demised outside of the trauma unit, and whose follow-up time to the study will thus require early censoring

4.2. Data Safety & Monitoring Plan

ChildSafe data will be personally retrieved by one of the Co-Investigators, from the ChildSafe Safety Centre at RCWMCH, by means of a solid state flash drive. Census Data will be accessed via Statistics SA's online web tool. RCWMCH Mortality Data will be accessed via the Western Cape Provincial Health Data Centre. Confidential datasets will be stored on the Co-Investigators password protected laptop. Once datasets have been matched by hospital folder numbers, these will be removed and replaced with anonymous study-specific numbers. A reference table will be stored in a separate, password-protected Excel file, on a solid state flash drive, linking folder numbers to study numbers. It will be kept in the Co-Investigator's access-controlled provincial work office. All patients with suspected abuse will be linked back to folder numbers, and these will be relayed to Childsafe.

4.3. Data Analysis

All data analysis will be completed on the work laptop of the Co-Investigator. This laptop is under lock and key, and is password and firewall software protected. Once datasets have been matched, the de-identified data will be stored in a password protected Microsoft Excel (2010) spreadsheet and pivot table. A reference table linking folder numbers to study-specific anonymous numbers will be kept in a password-protected Microsoft Excel (2010) spreadsheet on a separate solid state flash drive, which will be kept in the co-investigator's access-controlled provincial work office.

Data will be analysed using a combination of Microsoft Excel, STATA, and ArcGIS. Patients' records will be analysed to determine the occurrence of repeat presentations, until the age of 13 years, at which point their time in the study will be censored. Statistical procedures will be used to describe and compare patient characteristics at first presentation, of those with repeat injuries to those with single injuries, using means/medians and proportion with appropriate parametric or non-parametric statistical tests.

Similar procedures will also be utilised to determine the characteristics of patients and patterns of injury at second, third and later presentations. Individual and census-level risk factors for repeat presentation will be then be identified using (i) Ordinal Logistic Regression to determine the risk factors for second, and three or more presentations and (ii) Poisson Regression for the number of repeat presentations. Data will be backed up to an encrypted solid state flash drive, which is owned by and will remain in the Co-Investigator's possession at all times during data collection and analysis.

5. Description of risks and benefits

5.1. Potential risks & discomforts

This observational research process is not anticipated to have any physical, psychological, economic or legal risks.

5.2.Risk classification

The overall risk of the study is minimal – the probability and magnitude of harm anticipated is no greater than the harm or discomfort encountered when providing presenting information to healthcare facility staff. All patients included in the study have already been identified as having suffered intentional or unintentional injuries by trained healthcare professionals. The main risk to patients whose data the study will utilize is due to breach of data confidentiality, which will be minimized as follows;

5.3. Risk minimization

Participant study information will be anonymized by using simple study generated participant identification numbers after study datasets have been linked. All personal identifying information (e.g. name, patient folder number) will be removed from the database.
A folder number – study number reference table will be stored in a separate, password-protected Excel file, on a solid state flash drive, linking folder numbers to study numbers. It will be kept in the Co-Investigator's access-controlled provincial work office.

Individual patient address information will not include specific residential address (such as street name and number), only suburb details. Individual patient presenting information and residential data will not be shared with hospital staff, provincial administration, or any other institutions or persons Laptop access control, password protection, and data encryption will be maintained at all times. Data will be disposed of one once data analysis is complete and the necessary reports have been generated, which is estimated to be complete by June 2017.

5.4. Potential benefits

The results may not have direct benefits to patients whose data is contained within the ChildSafe Database. Clinicians have already identified patients of probable and suspected abuse in the datasets, and have referred such patients to the RCWMCH social worker and the South African Police Services, as required. Thus the chance of newly identifying cases of abuse in the datasets are low.

The results of data analysis may however yield information which indicates the presence of occult abuse or neglect in patients with apparently unintentional repeat injuries. Although this is a retrospective review, a list of repeat injury case folder numbers, identified through the study, where there is evidence of possible occult abuse or neglect, will be reported to the Head of the trauma unit at RCWMCH, who can then verify whether mandatory reporting and investigation has been carried out, and ensure that such reporting and investigation is completed if not yet undertaken.

The results of data analysis may yield significant individual and ecological-level risk factors for repeat injuries, allowing for a profile determination of first presentations with a higher likelihood of repetition, for patients with both intentional and uninentional injuries.

The results of the study may be of benefit to future RCWMCH patients, their parents, family members and communities, as the information generated may be utilised by ChildSafe South Africa and other Child Health Promotion NGO's to plan further upon-discharge health promotion and injury prevention activities at ChildSafe South Africa and within patient's communities.

5.5. Harm: Benefit Ratio

The risk of harm due to the research process is minimal. Although there are no direct benefits to study patients, there is considerable population-level benefit to be derived from healthcare promoters understanding which Unintentional Injuries are likely to recur, and thus which type of Health Promotion needs to be prioritized in-hospital, upon discharge and in community forums.

The data may allow the generation of a list of occult cases of abuse or neglect, which may be of use to Childsafe, and of benefit to child victims of abuse or neglect who present to RCWMCH.

6. Informed Consent Process

Due to the considerable size and timespan of the Childsafe trauma database, a waiver for the need for formal written consent is requested. Obtaining written consent from approximately all 95 000 patients (or parents of patients) contained in the database would be a logistical improbability, due to the sheer number, the geographical distance, unavailable or incorrect contact details, and the level of mobility inherent in any population over a twenty year length of time.

Whilst it is theoretically possible to contact parents of children injured more recently, for instance over the last 5 years (which still represents a formidable number of patients), this small a sampling timeframe is insufficient given the objective of the study – which is to determine the rate of repeat injury in childhood, which by definition amounts to a maximum possible period of thirteen years. The failure to obtain this waiver of written informed consent would thus render the study infeasible, given the lack of time and financial resources available to conduct such a consent procedure.

7. Privacy & Confidentiality

Patient identity will be anonymised once the Childsafe Dataset is linked to the RCWMCH dataset, by the use of uniquely allocated participant identification numbers.
A separate reference table linking hospital numbers to study numbers will be kept in a password-protected Microsoft Excel (2010) spreadsheet, on a solid state flash drive, in the Co-Investigator's access-controlled provincial work office. Thus study data will not include any real world information which could be used to identify patients. Patient's personal identification details, including first, middle and surnames, identity number, or passport numbers will not be solicited or recorded. Patient's specific residential addresses (street numbers and names) are not included in the databases, only suburb details.

The co-investigator's laptop is also kept under lock and key within the aforementioned access controlled environment during the day, in a locked room at night, and is password and firewall software protected. Data will be backed up to a solid state flash drive, which is owned by and will remain in the Co-Investigator's possession at all times during data collection and analysis. All copies of primary study data will remain in the sole possession of, and be accessible solely to, the Co-Investigator, which will remain in an access-controlled office environment, for a period of two years, after which time all information will be deleted.

8. Reimbursement for Participation

Patients whose records are contained within the study database will neither be approached nor offered reimbursement for disclosure of further information.

9. Emergency Care and Insurance for Research-related injury

Research-related injury is not a possible outcome of this minimal-risk, retrospective observational study.

10. Study Closure Process

Once the data collection process is complete, analysis and report writing will commence, and is expected to be complete within a period of two calendar months. A briefing report will be written and delivered to ChildSafe South Africa. A presentation of the study results will be prepared for delivery at the Public Health Association of South Africa Conference, 2018. A report of the study results will be submitted to a local medical journal (such as the South African Medical Journal) for publishing consideration.

11. Conflict of Interest Declaration

Neither the Principal Investigator nor the Co-Investigator have a proprietary interest involving any agent, device or software being used within this study.

12. Ethical & Regulatory Compliance Declaration

This protocol is in compliance with the Declaration of Helsinki (2013). This study does not require approval by the Medicines Control Council. This study will seek written authorisation from the Head of Trauma Surgery at RCWMCH, and President of ChildSafe South Africa as well as the Chief Executive Officer of RCWMCH.

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Part B: Literature Review

Objectives of Literature Review

The objectives for conducting a search of the available literature prior to development of the study method, was (1) to generate an understanding of the distribution and determinants of both intentional and unintentional childhood injury globally and in Low and Middle Income Countries (LMICs) and South Africa in particular, and within this population of children, (2) to assess study methodologies of repeat injuries in children, and lastly, (3) to determine rates of repeat injuries in childhood from the published literature.

Search Strategy

Search terms used included a range of combinations of the following key terms determined by an initial scoping literature search: "Paediatric Injury" OR "Pediatric Injury", "Paediatric Trauma" OR "Pediatric Trauma", "Childhood Accidents" AND "Repeat" OR "Repeated" OR "Repeat Presentations" OR "Repetitive" OR "Recurrent" OR "Readmission" OR "Accident Proneness". Further descriptors and filter terms which were added to these included "Low Middle Income", "South Africa", "Red Cross War Memorial Children's Hospital", "Intentional Injuries", "Child Abuse", "Child Neglect" and "Unintentional Injuries".

Search engines used included *Google Scholar*, *PubMed*, *Cochrane Database*, *EMBASE*, and *ISI WebScience*. In addition to published academic literature, global and national institutional health reports, interviews and pertinent South African legislation were included in the review.

Search parameters were as follows; literature from within a 50 year retrospective period from the literature search start date was included. The search period extended from the start of January to end April 2017. Only English language articles were included, No geographical filter was applied but particular focus was given to injuries in LMICs and South Africa. A total of 64 articles were found, of which 16 formal studies are included below (Table 1).

Table 1: Repeat Injuries in Childhood Studies Summary

No	Author	Year	Country	Methodology	Population & Sample Size	Findings	Limitations
1	Eminson *et al.*	1971	Oxford, UK	Hospital-based record review (retrosp. cohort)	n = 2 013 Children ≤ 5 yrs with previous admission due to injury	Males: 2.64 per 100 person years Females: 2.11 per 100 person years Children with previous injury at double the risk of repeat injury than those without	Hospitalised injuries only. Unable to assess migration effect.
2	Graham *et al.*	1985	Little Rock, USA	Hospital-based survey (case-control)	n = 265 cases, 494 controls Aged 6-18 yrs with/out unintentional injury	Cases: 18.1% Frequency left-handedness Controls: 10.1% Frequency left-handedness OR: 1.80 [1.20; 2.72] (p<0.003] Parent 'clumsy' rating: 26%(L) vs 15%(R)	Common right-hand toys & tools. Subjective parental opinion societally biased.
3	Spady *et al.*	1988	Alberta, Canada	Health-facility data review (retrosp. cohort)	n = 96 000 Aged 0-10 yrs with 1 prior visit for an injury	Repeat injury extremely common: 73%. OR: Male: 1.42; Age<2yrs: 3.99; Aboriginal: 1.41, Welfare: 1.31 Moving district of residence: 1.04	Family/context/co-morbidity/cause not incl.>180 day defn for repeat injury.
4	Russell *et al.*	1991	National, USA	Health-facility data review and phone survey (retrosp. cohort)	n = 4 287 Aged 26-48 months Mothers of children w/ unintentional injury	Repeat injury mothers more likely to drink ETOH (p<0.05), be depressed & perceive children as 'difficult'. Males at greater risk for repeat injury (p>0.05).	Reliant on self-reported exposure data. Fathers or other caregivers not incl.
5	Junger *et al.*	1997	Quebec, Canada	Health facility data review and phone survey (prosp. cohort)	n = 1 770 Aged 0-42 months Caregivers children w/ unintentional injuries	Repeat injuries were predicted by: OR: Males: 2.01; 'Difficult' temper: 1.13 Mat. smoking: 1.68; Medication:1.54 Single mothers: 2.05	Reliant on self-reported exposure data. No ETOH data. Possibly intentional.
6	Wadsworth *et al.*	1970	National, UK	Health facility data review and phone survey (retrosp. cohort)	n = 17 000 Aged 5 years Mothers of children born in one week of 1970	Repeat injuries more likely in Males, young maternal age, moving residence, impulsive childhood behaviour, step- and single-parent families.	Reliant on self-reported exposure data. No supervision, enviro/context data
7	Bijur *et al.*	1970	National, UK	Health facility data review and interview survey (retrosp. cohort)	n = 10 394 Aged 10 years Parents children born in one week of 1970	Repeat injuries assoc. with multiple prev. injuries, males, aggression, young maternal age (20-24), maternal depression, family context, many older siblings	Reliant on self-reported exposure data. Substantial individual variation.
10	Husband & Hinton	1968	London, UK	Health facility interview survey (case series)	n = 24 families Aged 2-14 years Presenting with third unintentional injury	5.7 injuries per child. 29% non-married. Repeat injuries assoc. were with extrovert-type child personality, coexistent psychiatric and organic illness in family	Reliant on self-reported exposure data. No comparison group studied.
11	Head & Husband	1972	Nottingham UK	Health facility data review and interview survey (prosp. cohort)	n = 600 Aged 3-11 years Presenting with unintentional injuries	Annual incidence rate of 0.07 injuries per child, 29% of all study participants injured Of this, 11% experienced repeat injuries. 3% of the cohort had 27% of all injuries.	Study not formally published.
13	Ordanana *et al.*	1994	National, UK	Health facility data review and interview survey (retrosp. cohort)	n = 1 027 Aged 0-5 years. Mothers of same-sex pair twins.	Child-specific environmental factors explained 60.2% and family factors 39.8% of variance in recurrent injuries. Unlikely that injury-proneness is innate, more likely environmental	Reliant on self-reports & maternal recall bias. Unable to determine intent & RF temporality
14	Damashek *et al.*		Missouri, USA	Consecutive self-completed reports and interviews (prosp. cohort)	n = 149 Aged 15-36 months Mothers recall of childhood injury events.	2.38 injuries per child per 2-week period. Recurrent injury assoc. with risky behaviour. Higher frequency injury rate mediated by mothers with an external locus of control.	Study sample limited primarily to Caucasian Upper-Middle class. Narrow age range.
15	Braun *et al.*	1993	Denver, Colorado	Health facility claims data review (retrosp. cohort)	n = 817 Aged 0-36 months Children born at Denver Medical Health Centre in 1993.	33% injured, with 7% injury recurrence, assoc. with young maternal age (<18 yrs), substance abuse, mental illness, single primary caregiver, or family with history of violence. Also likely to attend for other acute or chronic ailments.	No injury prevention assessment. Specific to urban low SES. Social factors more likely reported in injured pts.
16	Deans *et al.*	2007	Columbus, USA	Health facility claims data review (retrosp. cohort)	n = 1 361 Aged 0-4 years Children with 1 birth claim & non-birth related intended injury	40% of study population presenting with suspected or confirmed abuse had a recurrent episode within 2 years. Recurrence assoc. with age<2.5 years, rural origin, suffer dislocation/open wound	35% of sample had break in Medic-Aid enrolment. Childcare agency LTFU. NAI Dr under-reporting.

Abbreviations: LTFU – Loss To Follow Up; ETOH – Ethanol; NAI – Non-Accidental Injury; Yrs – Years; OR – Odds Ratio; L – Left; R – Right; w/ - With; Incl. – Including; Defn – Definition; Enviro – Environment; RF – Risk Factor; Prosp. – Prospective; Assoc. – Association; SES – Socio-economic Status.

Introduction

Traumatic injury, defined as 'the physical damage that results when a human body is suddenly subjected to energy in amounts that exceed the threshold of physiological tolerance or is deprived of one or more vital elements'[1], remains one of the leading causes of childhood morbidity and mortality in the world today. Research and advocacy regarding the distribution and determinants of such injuries has traditionally focused on one of two supposedly distinct aetiologies, namely those of 'Accidental' or 'Non-Accidental injuries'. Changes in the conceptualisation of injury causation over time have resulted in these older terms being replaced by the more pointed terms 'Intentional' or 'Unintentional'.

The older terms have fallen out of favour in more recent research, as the use of the word 'accidental' belies the fact that injuries are more likely to occur within certain contexts, and are therefore not simply random events, but predictable and preventable outcomes of a model of causation, with a range of individual and group level exposures.[2]

The WHO has broadly defined Intentional Injury in children as 'child abuse or maltreatment (which) constitutes all forms of physical and/or emotional ill-treatment, sexual abuse, neglect or negligent treatment or commercial or other exploitation, resulting in actual or potential harm to a child's health, survival, development or dignity in the context of a relationship of responsibility, trust or power.'[1] Although Intentional Injury of children may be divided into interpersonal violence, self-infliction or collective violence (such as war or genocide)[3], research in the field has historically focused on the behaviour of adults committing acts of interpersonal violence (abuse) against children.

Conversely, Unintentional Injuries have simply been defined as injuries in which there is 'no identifiable evidence of predetermined intent.'[4]

Causative Framework

The current most widely utilised epidemiological framework of injury causation is the Haddon Matrix[5], which was conceptualised forty years ago, in the context of traffic safety. It allows for the comprehensive description of injury events by making explicit the Agent, Host and Physical-Social Environment factors which potentiate the risk of injury and debilitating outcome.

Table 2: The Haddon Matrix of Injury[5]

Injury Event Phases	Aetiological Dimensions		
	Agent: Object/Substance	Host: Child & Parent	Enviro: Physical-Social
Pre-Event	Water kettle unsecured	Childhood naiveté	Poor lighting
Event	Kettle fall with hot water burn	Lack of supervision	Kettle wiring within reach of floor
Post-Event	Burn injury dressings	Burn First Aid knowledge	Informal area ambulance access

These factors are considered in chronological order; as being pertinent to either pre-event, intra-event or post-event time frames. These then map to primary (pre-event), secondary (event) and tertiary (post-event) prevention activities respectively. The vast differences in disease burden and outcome severity between developed and developing countries, with differing environmental contexts, would appear to corroborate this framework.

In addition to the time and aetiology dimensions above, Runyon *et al*. (1998) have more recently proposed the addition of a third 'value criteria' dimension to the Matrix – which may be used to weigh and determine policy interventions based on relative effectiveness, cost, equity and other considerations.[6]

Ultimately, the model affirms the importance and potential of health promotion as a tool with which to generate understanding of the multifactorial nature of injury causation, particularly for parents and caregivers. Optimal supervision of children within the domestic environment is dependent on numerous educational, socio-economic and inter-personal factors. This is also in accordance with the Primary Health Care approach, which emphasizes the 'education regarding the control and prevention of prevailing health problems' and the 'promotion of maximum community and individual self-reliance in the control of primary health care.'[7] Prevention is of primary importance in the field of childhood injury, which affects more than 2000 families around the world per day[1], carrying a heavy burden in terms of disability as well as years of life lost.[8]

The Child Injury Death Pyramid highlights the fact that childhood injury results in varying levels of severity, only the most urgent and distressing of which will result in presentation to hospital for treatment by trained healthcare professionals. As such, hospital level studies are unlikely to provide the means by which to estimate the population-level incidence rates of all injury events occurring in communities.[1]

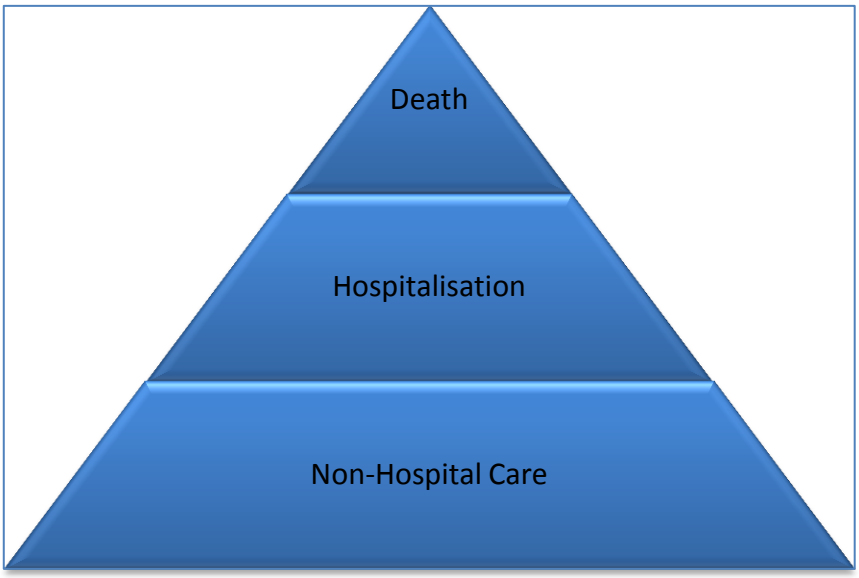

Figure 1: The child injury death pyramid

Unintentional Injury Statistics

Unintentional Injuries (UI) alone have been estimated to cause the death of over 830 000 children annually.[1] This burden of disease due to UI is unevenly spread globally, with the vast majority of incidence, deaths and long term disability being concentrated in income disparate Lower and Middle Income Country (LMIC) economies such as South Africa, where domestic safety protocols and guidelines are either unwritten, unknown or underutilized, living conditions lead to greater hazard exposure, and access to acute trauma care and long term rehabilitation is severely lacking. Other stressors which impact on the quality of adult supervision in such countries include lack of access to economic opportunities, substance abuse, insufficient housing and sanitation, marital and family discord and high fertility rates.[1]

The five major categories of unintentional injury affecting children globally include Road Traffic Incidents (RTI's), Drowning, Burns, Poisoning and Falls. Rates of injury vary by age group, by gender and by country. New-borns and toddlers are most at risk of domestic hazards, whilst those above the age of four are increasingly exposed to risks outside of the

home, such as RTI's and drowning. Injury rates are equivalent for boys and girls until the age of five, at which point the proportion of boys unintentionally injured increases dramatically; reaching 86% of injuries among children aged 15 years.[1]

Intentional Injury Statistics

Intentional Injuries (II) in childhood form a far smaller proportion of morbidity and mortality, but have received widespread attention from international organizations such as the World Health Organisation (WHO) and the United Nations International Children's Emergency Fund (UNICEF). The WHO have estimated that in the year 2000, 57 000 childhood deaths under the age of 15 were attributable to homicide, with the very young (age group 0-4) being at greatest risk.[9]

Major categories of interpersonal intentional injury against children include physical abuse, sexual abuse, emotional abuse and neglect.[10] Physical abuse is most easily measured in fatality rates – with risk being directly correlated to country income level; High Income Countries (HICs) have recorded homicide rates of 1.8 (girls) and 2.2 (boys) per 100 000 per annum, with low income countries recording 5.1 and 6.1 per 100 000. The highest rates were found in 0-5 year olds in Africa, recorded at 12.7 and 17.9 per 100 000. Data on non-fatal abuse comes from heterogeneous sources, vary greatly, and are non-comparable due to differences in cultural definitions of abuse and neglect between countries.[10] Similarly, rates of sexual abuse in children also vary greatly, being dependent on different legal definitions and data collection methods used. International studies have found mean lifetime prevalence rates of childhood sexual abuse to be 20% in women and 1-10% in men.[11]

Defining psychological abuse is also a difficult task, due to cultural heterogeneity, but has been posited to include shouting or cursing at children, as well as threatening children with deprivation of food or shelter. Neglect has been defined as 'the failure to meet children's physical and emotional needs, to protect them from danger, or obtain medical or other services when needed,[12] although it has often been operationalised in research terms as the presence of poverty or hunger.

Despite these statistics, Childhood Injury in LMICs has long been a neglected field of study, research and healthcare systems development, due to multiple reasons. Although the planning, establishment and co-ordination of dedicated trauma services has been proven to reduce disability and mortality, the need for such services has been overshadowed by the ubiquity of Communicable and Nutritional Diseases in LMICs, to which the bulk of health budgets are dedicated.[13] Internationally, global priorities and finances have thus also followed similar themes.

The Millennium Development Goals advocated for a general reduction in child mortality (MDG 4), drawing particular attention to poverty, hunger eradication and infectious diseases, with no mention made of childhood safety from injury.[14] Neither is the topic mentioned in the United Nations' newly established Sustainable Development Goals.[15]

South African Statistics

South Africa is a markedly income-disparate, middle income country. It has a population of approximately 54 million, of which 18.5 million (ie one-third) are children under the age of 18 years old.[16] Of these, 63% of children belong to families living under the upper bound poverty line, concentrated in the rural parts of the country. It is thus not surprising that the country continues to record disappointing childhood mortality statistics, with neonatal, infant and under-5 mortality recorded at 11, 28 and 39 per 1000 live births respectively.[17] A 2010 report by the World Health Organization found RTI's to be the cause in almost 50% of fatal paediatric injuries in Cape Town; however cases of instant fatality would obviously not present to hospital trauma units, nor are they at risk for repeat injury.

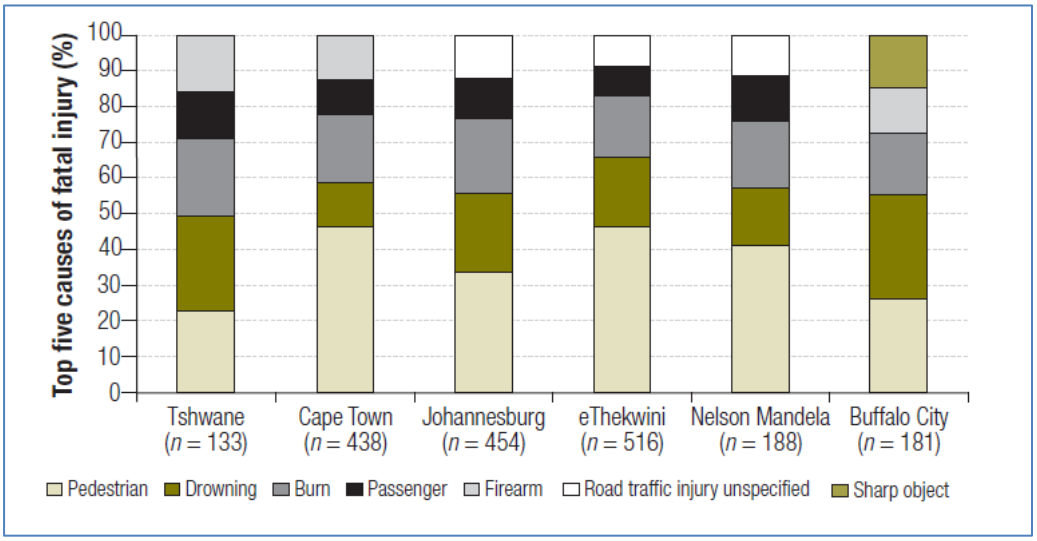

Figure 2: Top five causes of fatal injury in children aged 0-14 yrs in South African cities[51]

Injuries feature prominently across the top causes of mortality in South Africa children, and even when not fatal, contribute towards the prevalence of permanent disability and reduced quality of life.[18] Within the age group 0-5, road traffic incidents, burns, violence and drowning all feature in the top 20 causes of death. As children get older, they spend greater amounts of time outside the home, and thus causes of death external to the household rise in importance – with road traffic incidents, homicides and burns claiming a far greater

proportion of lives after the age of 4 years.[19] To date in South Africa, there have been no studies of repeat childhood injuries or 'accident-proneness' performed on local cohort data.

National Injury Mortality Surveillance Data shows that in urban regions, the most common causes of injury-related deaths in those under the age of 14 are road traffic accidents, drowning, burns and gunshots, with large differences in mortality causes between genders, age groups and ethnicities.[20] Numerous, heterogeneous childhood injury studies have taken place in the country. At RCWMCH, analyses of the trauma unit database have been largely descriptive in nature. A 10 year review of the most common mechanisms of injury of 88 822 paediatric presentations to the Unit found that Falls accounted for the highest proportion with 21%, followed by transport related injuries at 13%, being struck by or against an object at 10%, Burns constituted 8% and Foreign Body ingestion at 4%. Non-Accidental Injuries constituted only 3% of the entire sample.[52]

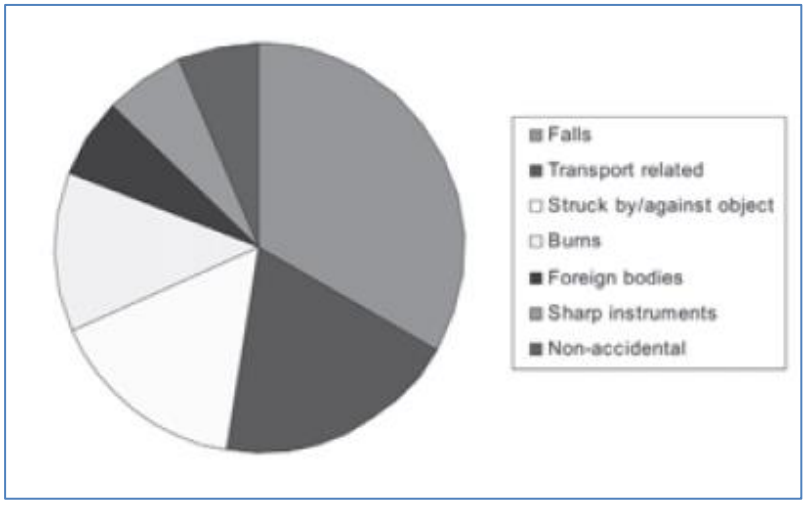

Figure 3: Most common injuries in patients admitted to Red Cross War Memorial Children's Hospital Trauma Unit[52]

The Optimus Study of intentional injury, a household and population survey, conducted in 2015, found alarmingly high rates of physical and sexual abuse in South African children. By

age 15, one third reported being physically assaulted; one fifth (of girls as well as boys) reported having been sexually assaulted, and one sixth reported some form of neglect.[21]

South African Legislation

Both international and national legislation apply to the handling of cases of child abuse. The UN Convention on the Rights of the Child advises signatory countries to 'take all appropriate social and educational measures to protect the child from all forms of physical or mental violence, injury, neglect or negligent treatment, maltreatment or exploitation including sexual abuse'. The African Charter on the Rights and Welfare of the Child similarly places responsibility upon member states to support child abuse victims and their caregivers.[22]

Within South Africa, the Constitution of the Republic[23] ("Constitution") states that every child has the right to be protected from maltreatment, neglect, abuse and degradation'. To further this end, Section 110 of the Children's Amendment Act[24] requires healthcare professionals to report suspected instances of abuse, neglect or maltreatment to child protection services, social development services or the police, whilst the Sexual Offences Act[25] imposes responsibilities on all citizens to report instances of child sexual exploitation to police services.[26]

Although compliance to mandatory legislative reporting requirement has been noted to be a challenge[26], there have been examples of significant success in decreasing rates of childhood injury. The Firearms Control Act[27] which was passed in 2004 after heavy parliamentary

lobbying by both pro- and anti-gun lobby groups preceded a sustained and significant reduction in firearm-related childhood injuries presenting to the Red Cross Children's Hospital in Cape Town.[28]

Repeat Injuries in Childhood

The formal investigation of repetitive unintentional childhood injury began in the 1960's, but has been largely confined to hospital-level data from North America or Europe, with studies from the USA heavily predominating. The only developing country to have conducted similar research is China. As such, repetitive injury has been studied as an outcome largely due to 'accident-proneness', or in other words, largely as a result of risk factors intrinsic to the individual, which predispose to injury.

Historically, studies of the phenomenon of repeat injuries have operationalised accident-proneness in populations via three distinct methods; firstly, as an individual's number of repeat presentations for medical care, secondly as the categorisation of individuals into low, normal or high accident proneness categories, or thirdly as the comparison of single-accident to repeat-accident (accident prone) victims. Even within this narrow view of repeat injuries, conducted on the basis of individual "accident proneness" alone, there has been significant difference in the type of studies performed, the age groups studied, and the definition of accident-proneness. The majority of repeat childhood injury studies have investigated rates of presentation to medical facilities following unintentional injury.

The operationalization of repeat injuries as accident-proneness is to be expected; research in developed countries has tended to focus on individual risk factors – environmental risk in these countries is thought to have been minimized to a greater extent through the use of safety guidelines, policy and legislation, thus environmental risk factors are assumed to play a lesser role in injury causation.

In 1986, the Oxford Data Linkage study found that children who had previously been admitted for an injury had approximately double the risk of presenting again for admission due to injury, than children of the same age and gender who had never done so.[29]

Researchers focused on studying individual child characteristics have noted that although recurrent child injuries have been established as multifactorial in nature, the role of individual 'accident proneness' should not be discounted entirely. In a case-control study of dexterity, Graham *et al.* noted that left-handedness has been proven to be linked to recurrent childhood injury by numerous studies, and draws on this observation to advocate for attention being paid to individual childhood motor skill development deficits (or in this case the left-handed use of right-hand designed equipment).[30]

However, in LMICs such as South Africa, markedly differential rates of childhood injury are still observed and have been studied as multifactorial outcomes, related to socioeconomic context **(**family size and structure, living conditions), agent exposure, and individual variation, both in co-morbidities; be they musculo-skeletal, proprioceptive, behavioural or

neurocognitive disorders, as well as features of normal childhood; curiosity, impulsivity and excitability, amidst a developing cognitive ability and level of maturity.[31] The complex interplay of these various factors ultimately determines the risk of injury to each individual child.

Repeat injury studies have operationalised accident proneness in study populations via three distinct methods; firstly, as an individual's number of repeat presentations for medical care, secondly as the categorisation of individuals into low, normal or high accident proneness categories, or thirdly as the comparison of single-accident to repeat-accident (accident prone) victims.

Even within this narrow view of repeat injuries conducted on the basis of individual "accident proneness" alone, there has been significant difference in the type of studies performed, the age groups studied, and the definition of accident-proneness. The majority of repeat childhood injury studies have investigated rates of presentation to medical facilities following unintentional injury.

Canadian research from 1988 investigated longitudinal, population level data of approximately 96 000 children between the ages of 0 and 10. Data was obtained from multiple healthcare providers including emergency centres and physicians' offices in Alberta, Canada. The prevalence of repeat injuries was extremely common, with 73% of the total population having presented more than once, with boys more likely to be injured, or be

injured repeatedly. Those children who came from aboriginal Canadian populations or whose families were on welfare were also more likely to suffer repeat injuries. Curiously, those whose families moved between health Sub-Districts during the study were also at risk of having repeat injuries. Finally, those whose first injury occurred early in life were also understandably at greater risk of repeat injury, simply as they had a longer time in which to present again before reaching age 10.[32]

These findings were not able to be interrogated thoroughly, due to the lack of contextual information available to researchers from their health insurance data, however it was posited that the reasons for repeat injuries stemmed from contextual exposures in the children's homes, which were determined by group characteristics such as socioeconomic status and ethnicity. The researchers noted a small proportion of the study population who presented an excessive number of times, this being defined as greater than 15 separate injury episodes, each at least 180 days apart from each other, however they were unable to determine if this was due to individual or contextual risk factors. No mention was made of suspected child abuse, or whether this was an exclusion criterion from the study.

Community-based surveys more commonly provide in-depth analyses of smaller cohorts of recurrent injuries, by investigating family and household characteristics. A secondary analysis of sample data from the American National Maternal and Infant Health Study[33] found different risk factors for recurrence across different ethnicities. Recurrence in African American homes was associated with maternal alcohol use, whereas in households classified as White, recurrence was significantly associated with male children and unmarried mothers.

Poor maternal health status and the presence of Ipecacuhuana (an emetic) was common to both ethnic groups.[33] In either group, it was noted that it was possible to identify children at high risk for injury recurrence.

Comprehensive analysis of family characteristics has even led to the identification of pre-natal and peri-natal risk factors for repeat unintentional injuries. Junger *et al*.[34] found that repeat unintentional injuries were associated with maternal smoking during pregnancy, being on prescription or non-prescription medication, having male children, or children with 'difficult' temperament, or being a single mother, or having a poor perception of self-efficacy as a mother. These variables may be markers of socio-economic status.

Similarly, in an analysis of retrospective cohort data including approximately 17 000 children[35], found that recurrent accidents were significantly linked to male children, low maternal age, a frequently moving household, as well as childhood behaviour such as impulsivity increased the risk of recurrent injury. A greater proportion of children with recurrent injuries were found to come from homes with stepfamilies (17.8%) or single parents (13.1%) than two-parent families (11.1%).[35]

Results of the 1970 British Birth Cohort Study were used to assess injury recurrence in approximately 10 000 children who had presented with a first injury between 0 and 5 years of age.[36] Recurrent injury was found to be associated with multiple previous injuries, as well as male sex, aggressive child behaviour, young maternal age and interestingly having many

older, but fewer younger siblings. The researchers noted that maternal depression and family composition were also related to recurrent injuries, and that these formed a complex interaction with aggressive child behaviour to produce higher rates of recurrent injury in certain cohorts of children.

Husband *et al.* investigated the phenomenon of repeated injuries in the 1970's in the UK[37] as a distinctly 'family problem', and rejected the notion that it could be attributed to 'accident proneness' on behalf of the individual patient, without an extensive enquiry into the home and family environment in which these injuries were occurring. A study performed by the same investigators in 1972 on a group of 600 children from Nottingham found an annual incidence rate of 0.07 accidents per child, with 29% of children presenting with an injury over that period.[38] Of great concern, they noted that due to recurrent injury, 3% of those injured accounted for almost a third of presentations to hospital trauma units.

A sub-cohort analysis of children with increased accident rates was then conducted,[39] which found that such children had extrovert personalities and were deemed to be daring or fearless but that there were other family characteristics which they also had in common, thus corroborating the Husband *et al*. prior 'family problem' assertion[37] . Families tended to be large, with at least four or more children, living in houses which were overcrowded, and had little space for safe play. Half of recurrent injury victims had immediate family members with serious physical or psychiatric illness. Approximately a third of children with high accident rates came from single parent, divorced or unmarried families. The authors posited that recurrent injuries are most likely linked to excessive impulsiveness, but that this 'acting out'

is actually a symptom of families which are subjected to emotional, financial and physical stresses, similar to the family psychopathology underlying the onset of childhood enuresis or recurrent abdominal pain.[40] Crucially, family psychopathology was noted by Sobel[41] as the root cause of accidental poisoning, and not merely the presence and access of household chemical exposures. This has important ramifications for the efficacy of safety education versus intensive family psychotherapy in the prevention of further accidental injury.[41]

Some studies have been designed to differentiate group level from individual level causality. Ordanana *et al.* investigated individual latent genetic and environmental characteristics in a cohort of approximately 1000 same-sex twin pairs, finding no evidence of a genetic basis for accident proneness, based on the occurrence of recurrent injury in monozygotic twins.[42] Recurrent injury was instead found to be strongly associated with familial factors, including single mothers, socio-economic disadvantage and childhood behavioural externalization, such as impulsivity and hyperactivity. A more complex interpretation of this finding was offered by Damashek *et al*.[43] By regression analysis of 149 mother's recall of childhood injury events coupled with psychometric analysis, it was found that a higher frequency injury rate was mediated by mothers with an external locus of control; being of the belief that such injuries and the circumstances which led to them were due to factors which they could not control – such as other people, the environment or a higher power.[43] Thus the incident was very much due to both individuals in the parent-child complex, and their manner of relating to each other.

According to research conducted in Denver, Colorado, children with more than one injury during the study period were more likely than those with single injuries to have multiple social risk factors, with recurrent injury being significantly associated with maternal substance abuse, mental illness, age under 18 years, as well as having a single primary caregiver, or coming from a family with a history of violence. Children with recurrent injuries were also more likely than others to attend health facilities for other unconnected chronic and acute health requirements.[44]

Other studies have however investigated the phenomena of recurrent injury as an indicator of intentional injury. Deans *et al*.[45] performed a retrospective cohort study of 1361 children presenting with injuries due to confirmed as well as suspected abuse over a four year period in Ohio, USA, using insurance claim records from the year 2014. Worryingly, 26% of the study population went on to experience a recurrent episode of intentional injury within one year of a first injury, and 40% did so within 2 years. Those with recurrent intentional injury were more likely to be less than 2.5 years at first presentation, come from a rural area, and suffer a dislocation or open wound at this presentation, than those who presented only once.[45]

A systematic review of repeat injury studies was conducted by Visser *et al*. in 2006,[46] which attempted to collate the various types of injury studies (population, community and facility-based) for meta-analysis. Included were childhood-specific repeat injury studies, as well as studies concerning other age groups. In their meta-analysis, the authors concluded that, within populations of patients either suffering from, or presenting for repeat injuries (as repeat injuries were defined heterogeneously by various studies), there are a sub-group of

patients who are at increased risk for repeat injuries, such that they present with greater frequency than that which would be expected due to chance alone.[46]

Questions which typically remain unanswered in studies of 'accident-proneness' is the contributory effect of environmental and socio-contextual factors to patient's increased risk of repeat presentation. In concluding their analysis, Visser *et al*. advise that a deeper understanding of the situations in which injuries occur is required to truly determine why certain individuals present recurrently for injury events, to facilitate a more comprehensive understanding of injury causation, and to better inform health promotion efforts designed to alleviate the resultant burden of disease.[46]

Conclusion

Injuries in childhood occur within a complex framework of causation related to the chronological interactions of Agent, Host and Environment; and have traditionally been conceptualised and researched separately as being brought about due to either Intentional or Unintentional aetiologies. However, they share similar factors, including age and gender, family size and structure and socio-economic status.

The predominance of HIC-based research in the study of repeat childhood injuries has resulted in a focus on individual and some family risk factors. These proximal risk factors are likely to be markers of more upstream factors, such as socioeconomic deprivation and

education status. Investigation of community-level risk factors may yield targets for more pro-active group-level interventions aimed at preventing injuries in high risk sub-populations.

Studies of repeat injuries have also generally tended to focus on hospital-level data, which although able to provide detailed information on patterns of complex and severe injuries, is generally unable to provide detailed contextual information regarding agent and environment-related factors which predispose children to an increased risk of injury. The study of repeat injuries has much potential; to confirm the basic premise of the Haddon Matrix (that injuries are not simply 'once-off', accidental events), to demonstrate the relationship between intentional and unintentional injuries, to predict which injuries are likely to recur, to determine which environments they are most likely to recur in, and to predict which children are most likely to present repeatedly for them. This would be of significant use to an LMIC such as South Africa, in which health promotion efforts are in need of reinforcing, and a shift in mind-set from cure to prevention is required, particularly in the field of childhood injury due to its debilitating consequences.

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Part C: Publication-ready Manuscript

South African Medical Journal

Article Title: Repeat Injuries in Childhood

Repeat Injuries in Childhood

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Abstract

Background: Injury remains a leading cause of childhood morbidity and mortality in the developing world. Probability of injury occurrence is influenced by agent, host and environmental factors. Studies of repeat injuries in childhood thus provide insight into factors in the epidemiological triad predisposing children to injury.

Objectives: The study objectives were to determine the proportion of children and the factors associated with repeat presentations to Red Cross War Memorial Children's Hospital Trauma Unit (RCWMCH TU) for all non-transport related injuries in childhood.

Methods: This was a retrospective cohort study using data from RCWMCH TU. We included children aged 0-10 years with first presentation from January 1997 to June 2013, and followed up until the earliest of age 13 years or June 2016. We assessed individual and population-level factors associated with repeat injury using multilevel Poisson regression. Child Dependency Ratios were derived from the 2011 national census.

Results: Between 1997 and 2013, 72 490 children under 10 years of age (59% male) presented to RCWMCH TU for the first time with injuries. After the initial injury, 9 417 (13%) presented with a repeat injury by 2016 and before age 13 years. After adjusting for health Sub-District, distance from RCWMCH TU and age at first presentation, factors associated with reduced repeat presentation were: injury identified as due to abuse (adjusted incidence rate ratio [aIRR] 0.6; 95% confidence interval [CI]: 0.4 – 0.7), fluid burn (aIRR 0.6; 95% CI: 0.6 – 0.7), foreign body ingestion (aIRR 0.7; 95% CI: 0.7 – 0.9), moderate and severe (vs minor) initial injury (aIRR 0.9; 95% CI: 0.8 – 0.9) and (aIRR 0.7; 95% CI: 0.6 – 0.8 respectively), whilst boys were more likely to have repeat injury presentations (aIRR 1.4; 95% CI: 1.4 – 1.5).

Conclusion: Repeat presentations constituted a substantial proportion of disease burden. Factors associated with repeat presentations were identified, strengthening the argument that injuries arise due to sustained exposure to host, agent and environmental risk factors. While it is reassuring that children with initial injuries due to abuse and severe initial injuries are less likely to present again, injury prevention education should not neglect patients with minor and unintentional injuries. The findings of this study suggest that post-injury health promotion activities should not exclude patients who present with minor injuries, and that targeted education and further research is indicated for specific injuries, including those due to non-height falls and injuries sustained whilst playing sport.

Introduction

Traumatic injury is a leading cause of morbidity and mortality in childhood. Globally, unintentional injuries alone account for over 830 000 child deaths annually.[1, 2] Injury risk is age and sex-dependent, with intentional injuries peak from 0-4 years of age, and unintentional injuries from 4-10 years of age, as children are increasingly exposed to risks both inside and outside the home.[3]

Childhood injury incidence, mortality and subsequent long-term disability are disproportionately concentrated in low and middle income countries (LMICs) such as South Africa (SA). In SA, domestic safety protocols and guidelines are unwritten, unknown or underutilized, resulting in living conditions with greater hazard exposure, and functionally sub-optimal access to paediatric acute trauma care and rehabilitation, due to lack of parental awareness. Van As & Stein note that childhood injuries are "less commonly due to intentional abuse and maltreatment, than the consequence of a failure to be aware of child injury and an appreciation of the need for appropriate intervention." [4] Injury theorists emphasize that injuries are not due to chance alone, but occur in preventable contexts and events, as illustrated by the Haddon Matrix[5, 6, 7] (Figure 1). Runyan expands on Haddon's original matrix, which in addition to Agent, Host, Environment and Phases of Injury, also delineates 'decision criteria' which can be used to determine which countermeasures to apply, such as considerations of equity and costs of interventions.[6] Identifying and addressing all factors and phases of the Haddon Matrix may aid in prevention of Repeated Injuries in Childhood (RIC). As childhood injuries in LMICs are a leading cause of both childhood mortality and permanent disability, first presentations for injury represent an opportunity to perform injury prevention education in a high risk population.[8, 9]

RIC have been investigated using either hospital attendance data or community-based surveys. Community-based surveys report on injuries for which caregivers have not sought external medical assistance, whereas hospital data-based studies report only on injuries requiring treatment and admission. North American and European hospital RIC studies focus on the quantification of 'accident-proneness', on the assumption that risk of injury is intrinsic to individuals, with environmental and agent factors being mitigated by policy, legislation and higher standards of living in these regions. However, a systematic review of RIC in low, middle and high income countries by Visser *et al.* concluded that within populations of injured children are a sub-group at increased risk for repeat injuries.[10]

There is limited evidence regarding agent and environmental factors that predispose children to injury in LMICs. To date, no study has determined the incidence of RICs in SA. However, staff at Red Cross War Memorial Children's Hospital Trauma Unit (RCWMCH TU) give anecdotal evidence of RIC (Prof. Sebastian Van As, personal communication). The objectives of this study are thus to: i) determine the proportion of children presenting with RIC, and ii) assess if RIC are associated with (a) agent factors (including aetiology, severity and intent), (b) host factors (including patient age and sex) and (c) environmental factors (including method of initial discharge, geographic location, domestic location, and census-derived Child Dependency Ratios). Transport-related injuries (both initial and repeat) were excluded from this study, as the risk factors for transport-related RIC are likely different from domestic RIC.

The findings of the study could thus be used to determine the burden of childhood injury due to repeat injuries, identify possible sub-population of injured children at greater risk for repeat injuries, and the agent, host and environmental factors which are associated with them. This would enable targeted injury prevention, education and advocacy for or implementation of environmental change.

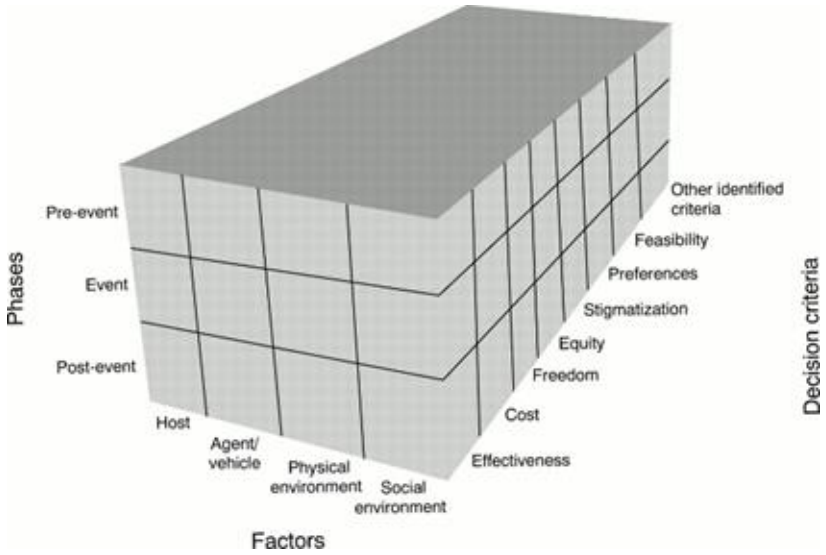

Figure 1: The Haddon Matrix of Injury[5]

Source: Runyan CW. Using the Haddon matrix: introducing the third dimension. Journal of Injury Prevention. 2015; 21:126-30.

Methods

Study Setting

This study was based at the RCWMCH TU in the Cape Town Metropolitan region of South Africa's Western Cape Province. Cape Town has undergone substantial growth during the study period, with a population of 2 563 095 in 1996, and 4 004 793 in 2016, approximately two-thirds of the total Western Cape province population.[11,12] The majority of patients presenting to RCWMCH TU reside in the Cape Town Metropolitan region (Figure 2).

Study Design

This study was a retrospective cohort analysis of RCWMCH TU data linked to census and mortality data.

Study Population, Inclusion & Exclusion Criteria

The study sample consisted of patients who presented to RCWMCH TU for the first time at age <10 years between 1 January 1997 and 30 June 2013, and were discharged alive following initial presentation. Follow-up tracking for RIC continued until 30 June 2016, with a total study period with follow-up of 19.5 years. Patients had to be resident within the Cape Town Metropolitan region at the time of first injury, and were assumed to be resident there until the end of the study period.

Only patients who contributed at least 3 years of person-time were included in the study population. Patient-time in days was calculated from the date of first injury presentation and censored at the earliest of either date of 13th birthday, date of demise as recorded by the Western Cape Provincial Health Data Centre, or the end of the study period on 30 June 2016.

Sample Size & Selection

Patients with both intentional and unintentional injuries of any severity (as assessed by RCWMCH TU clinicians) were included. Of more than twenty different first presentation aetiologies, the top five (which together accounted for more than 50% of all injuries) were described and included in the regression analysis. These included falling from a non-height level, being struck by or against an object or structure, falling from a height level, ingesting a foreign body or having a fluid burn. All transport-related injuries, both for first and repeat presentations were excluded, as transport-related RIC are assumed to have different risk factors to domestic RIC. Patients with poisoning were not included as these are not treated at RCWMCH TU.

Data Sources & Data Collection

Data was included from three sources

1. Hospital data from the RCWMCH TU,
2. Mortality data from the Western Cape Provincial Health Data Centre,
3. Geographic census data from the South African National Census (2011)

Hospital data was collected prospectively in the RCWMCH TU. Attending clinicians complete patient information sheets after initial examination and investigations. Nurses complete referral information once the patient is discharged.

Injury severity was graded according to the RCWMCH TU Abbreviated Injury Score (AIS):

1. Minor

Patients with minimal or no clinical evidence of injury as assessed by the attending clinician, who can be discharged from the TU directly and who only require advice on future prevention.

2. Moderate

Patients assessed as having moderate injury by the attending clinician, including all patients with head injury, all patients requiring suturing, all injuries requiring application of plaster of Paris and all patients requiring admission

3. Severe Injury

Patients who meet the criteria for moderate injury and are assessed by the attending clinician to have severe, life threatening injuries.

Patient information sheets were uploaded on a monthly basis to an Excel database. Hospital data was then merged with (1) provincial mortality data to identify patients who had deceased at or within 3 years of first presentation (thus requiring exclusion from the study) and (2) geographic census data using patient addresses to determine suburb-level Child Dependency Ratios (CDR). CDR was calculated as:

(Total number of children (aged 0-14 years) in suburb) / (Total number of adults (aged 15-65 years) in suburb) x 100

Patients were grouped into low, medium and high CDR categories based on tertile cut-off points.

Data Management & Analysis

Data was analysed using Microsoft Excel 2013, Stata V14, and ArcMap V10.2.2. Residential distance from RCWMCH TU was calculated using suburb geographic co-ordinates provided by the City of Cape Town. Follow up visits or repeat presentation <24 hours after initial presentation were excluded. Mortality was derived by linking Western Cape Department of Health folder numbers (which are unique patient identifiers) with Department of Home Affairs mortality records. This was done via application through the Western Cape Provincial Health Data Centre. Mortality data included deaths from all causes, both natural and non-natural, which occurred in the Western Cape during the study period.

The primary outcome was the proportion of children with at least 3 years follow-up since first injury presentation who experienced a repeat presentation for injury. Secondary outcomes were incidence rates for repeat presentation, by different host, agent and environmental factors. We then used a multilevel Poisson regression model to determine incidence rate ratios associated with following variables after adjusting for total days in study: age, sex, injury aetiology, intent (unintentional, self-inflicted or abuse), injury severity (minor, moderate or severe), discharge or transfer location (e.g. home, admission ward, child care agency), health Sub-District of origin, suburb-level CDR category, local place of injury (e.g. within or outside the home) and kilometre distance from RCWMCH (categorized as <10 kms, 10-20 kms, 20-30 kms and >30kms).

Study Limitations

This study was conducted at RCWMCH TU and therefore does not capture patient attendance information from other facilities in the City, although patients may have presented elsewhere during the study period, or migrated out of the province. It is also not possible to directly measure pertinent patient or household-level information such as quality of caregiver supervision, family size or structure, hence the use of ecological-level, census-derived CDR.

Ethics & Permissions

The study research protocol was approved by the University of Cape Town's Health Research Ethics Committee (HREC No: 343/2017), which included a waiver of individual consent. Permission was also sought and received from the Western Cape Department of Health Research Committee, the Chief Executive Officer of RCWMCH and the President of ChildSafe.

Results

Repeat Injuries

Over the study period, 72 490 of the children who presented to the TU met the inclusion criteria. Most (63 073, 87%) children presented once, however a substantial minority (9 417, 13%) presented with RIC (Table 1). A small number (1 970, 3%) experienced 3 or more injuries. The median time to repeat presentation was 1.8 (interquartile range [IQR]:0.7 – 3.7) years.

Host Factors associated with repeat injury

Repeat presenters were significantly younger at first presentation than single presenters, with median age of 2.7 (IQR:1.4 – 5.1) vs 3.6 (IQR:1.7 – 6.3) years; p<0.001). Males comprised 59% of all patients and 65% of patients with RIC. Males had a significantly higher incidence rate of RIC, with 2.6 (95% confidence interval [CI]:2.6 – 2.7) vs 1.9 (95%CI:1.8 –2.0) per 100 person years (py) for females; p<0.001) (Table 2). A significantly greater percentage of males; 14% (95%CI:14.1 – 14.8) repeat presented, vs 11% (95%CI:10.6 – 11.3) of females, representing a relative percentage difference of 3% (p<0.001). The adjusted incidence rate ratio (aIRR) for male vs female sex was 1.4 (95%CI:1.4 – 1.5; p<0.001).

Agent Factors associated with repeat injury

Aetiology

RIC rates differed according to aetiology of first injury. Patients presenting with falls from a non-height level were most likely to repeat present, with 14% (95%CI:13.7 – 14.9) doing so, whereas patients presenting with fluid burns were least likely to repeat present, at 7% (95%CI:6.6 – 7.8). In adjusted analysis, only falls from a non-height level remained significantly associated with increased RIC, with aIRR 1.1 (95%CI:1.0 – 1.1; p=0.001), compared to all other aetiologies. Patients who first presented with foreign body ingestion or fluid burns were significantly *less* likely to present with repeat injuries, with aIRRs for RIC of 0.7 (95%CI:0.7 – 0.8) and 0.6 (95%CI:0.6 – 0.7) respectively; with p<0.001 for both.

Intentional and Unintentional Injuries

Unintentional injuries formed the overwhelming majority of injuries, comprising 95% of injuries or up to 99% when excluding abuse categorized as “possible” by attending clinicians (Table 1). Intentional injuries were classified as being either due to abuse or self-infliction. Patients with definitive abuse were significantly *less* likely to repeat present, with an aIRR of 0.6 (95%CI:0.4 – 0.7; p<0.001). There was no significant difference in risk of RIC among patients who first presented with self-inflicted versus unintentional injury.

Injury Severity

Overall, 61%, 37% and 2% of patients first presented with minor, moderate and severe injuries respectively. Injury severity was inversely associated with RIC risk. Patients with initial minor injuries had the highest rate of RIC, with 2.6 repeat injuries (95%CI:2.6 – 2.7) per 100 py, whereas rates for patients with moderate and severe injuries were 1.8 repeat injuries (95%CI:1.8 – 1.9) per 100 py, and 1.2 repeat injuries (95%CI:1.0 – 1.5) per 100 py respectively. In adjusted analysis, those with moderate and severe injuries were found to have significantly lower rates of repeat injury than those with minor injuries, with moderate injury patients having an aIRR of 0.9 (95%CI:0.8 – 0.9), and severe injury patients having an aIRR 0.7 (95%CI:0.6 – 0.8), with both being significantly more likely to repeat present than patients with minor injuries (both $p<0.001$).

Environmental Factors associated with repeat injury

Child Dependency Ratio

Child Dependency Ratio, a population ratio measure of children to adults in an area, calculated from the 2011 National Census, was skewed to the left; a greater number of families had higher ratios of children to adults. The median CDR was similar for single and repeat presenters; 38.9 (IQR:33.9 – 42.3) and 37.9 (IQR:31.8 – 41.9) children per 100 adults respectively). In the adjusted analysis, there was no significant association between CDR and risk of RIC.

Discharge Method

Upon discharge from RCWMCH TU, patients were either admitted to wards, discharged with follow-up to the outpatient service, down-referred to other hospitals or primary healthcare facilities, or discharged directly home. Patients who were discharged directly home had the highest incidence rates of repeat injury, with 2.6 (95%CI:2.5 – 2.7) per 100 py.

Amongst patients referred internally in the hospital, those admitted to ICU had the highest rate of repeat presentation, with 2.3 (95%CI:1.6 – 3.2) per 100 py. Patients admitted to the burns unit had the lowest rates of repeat presentations, 0.8 (95%CI:0.7 – 0.8) per 100 py.

In the adjusted analysis, patients admitted to ICU were significantly more likely than those discharged home to have repeat presentations, with an aIRR of 1.5 (95%CI:1.1 – 2.1; $p=0.024$). This may be due to long term disability post-discharge from ICU, such as is seen in cerebral palsy, resulting in neurological fallout or musculoskeletal instability due to early insults to the developing brain. Patients referred to the burns unit had the lowest risk of RIC, with an aIRR of 0.5 (95%CI:0.5 – 0.6; $p<0.001$).

Table 1: Descriptive characteristics of first injuries for single vs repeat presenters at Red Cross War Memorial Children's Hospital Trauma Unit from January 1997 to June 2016

Variables		Repeat presenters	Single presenters	Total
Total patients		**9 417** [12.9]	**63 074** [87.0]	**72 490** [100]
Date of first injury		[Row %]	[Row %]	[Col %]
	➢ 1997 – 2000	**2 561** [15.1]	**14 419** [84.9]	**16 980** [23.4]
	➢ 2001 – 2004	**2 245** [14.6]	**13 158** [85.4]	**15 403** [21.33]
	➢ 2005 – 2008	**2 261** [13.4]	**14 642** [86.6]	**16 903** [23.3]
	➢ 2009 – 2013*	**2 350** [10.1]	**20 854** [89.9]	**23 204** [32.0]
Median days in study		**3 032** [IQR: 2155; 3 886]	**2 557** [IQR: 1 815; 3 486]	**2 621** [IQR: 1 853; 3 555]
Demographics		[Row %]	[Row %]	[Col %]
	Median age in years at 1st presentation	**2.7** [IQR: 1.4; 5.1]	**3.6** [IQR: 1.7; 6.3]	**3.6** [IQR: 1.6; 6.1]
	Sex			
	➢ Male	**6 127** [14.4]	**36 313** [85.6]	**42 440** [58.7]
	➢ Female	**3 274** [10.9]	**26 592** [89.0]	**29 866** [41.3]
Top 5 causes of injury**		[Row %]	[Row %]	[Col %]
	➢ Fall from non-height level	**1 986** [14.3]	**11 902** [85.7]	**13 888** [19.2]
	➢ Struck by or against	**958** [13.9]	**5 920** [86.1]	**6 878** [9.5]
	➢ Fall from height level	**867** [13.9]	**5 381** [86.1]	**6 248** [8.6]
	➢ Foreign body ingestion	**530** [10.8]	**4 387** [89.2]	**4 917** [6.8]
	➢ Fluid burn	**569** [7.2]	**7 357** [92.8]	**7 926** [10.9]
Injury intent**		[Col %]	[Col %]	[Col %]
	Self-Infliction:			
	➢ Yes	**364** [3.9]	**2 159** [3.4]	**2 523** [3.5]
	➢ No	**9 053** [96.1]	**60 914** [96.6]	**69 967** [96.5]
	Abuse:			
	➢ Yes	**60** [0.6]	**757** [1.2]	**817** [1.1]
	➢ Possible	**345** [3.7]	**2 503** [4.0]	**2 848** [3.9]
	➢ No	**9 011** [95.7]	**59 765** [94.8]	**68 776** [95.0]
Injury by severity/***		[Col %]	[Col %]	[Col %]
	Abbreviated Injury Score:			
	➢ Minor	**6 569** [69.8]	**37 850** [60.0]	**44 419** [61.3]
	➢ Moderate	**2 737** [29.1]	**24 003** [38.1]	**26 740** [36.9]
	➢ Severe	**109** [1.2]	**1 215** [1.9]	**1 324** [1.8]
Discharged or transferred to		[Col %]	[Col %]	[Col %]
	➢ Home	**6 161** [65.5]	**34 957** [55.4]	**41 118** [56.7]
	➢ Absconded	**32** [0.3]	**221** [0.4]	**253** [0.4]
	➢ PHC# Clinic	**367** [3.9]	**2 185** [3.5]	**2 552** [3.5]
	➢ Other Hospital	**34** [0.4]	**286** [0.5]	**320** [0.4]
	➢ RCWMCH Out Patients	**2 388** [25.4]	**19 012** [30.1]	**21 400** [29.5]
	➢ RCWMCH Ward	**157** [1.7]	**1 512** [2.4]	**1 669** [2.3]
	➢ RCWMCH Burns Unit	**248** [2.6]	**4 675** [7.4]	**4 923** [6.8]
	➢ RCWMCH ICU##	**20** [0.2]	**166** [0.3]	**186** [0.3]
	➢ Childcare Agency	**5** [0.1]	**54** [0.1]	**59** [0.1]

Location where injury occurred		[Row %]	[Row %]	[Col %]
	Health Sub-District:****			
	➢ Eastern	**50** [3.8]	**1 270** [96.2]	**1 320** [1.8]
	➢ Klipfontein	**3 573** [17.8]	**16 555** [82.3]	**20 128** [27.8]
	➢ Western	**1 622** [16.1]	**8 460** [83.9]	**10 082** [13.9]
	➢ Tygerberg	**772** [12.2]	**5 546** [87.8]	**6 318** [8.7]
	➢ Mitchells Plain	**1 497** [11.6]	**11 467** [88.5]	**12 964** [17.9]
	➢ Southern	**998** [11.5]	**7 661** [88.5]	**8 659** [12.0]
	➢ Northern	**36** [5.5]	**620** [94.5]	**656** [0.9]
	➢ Khayelitsha	**381** [5.1]	**7 159** [[94.9]	**7 540** [10.4]
	➢ Unknown	**488** [10.1]	**4 335** [89.9]	**4 823** [6.7]
		[Col %]	[Col %]	[Col %]
	Place:			
	➢ Own Home Inside	**5 079** [53.9]	**31 839** [50.5]	**36 918** [50.9]
	➢ Own Home Outside	**1 633** [17.3]	**11 462** [18.2]	**13 095** [18.1]
	➢ Other Home Inside	**218** [2.3]	**1 618** [2.6]	**1 836** [2.5]
	➢ Other Home Outside	**182** [1.9]	**1 527** [2.4]	**1 709** [2.3]
	➢ Road or Pavement	**229** [2.4]	**1 756** [2.8]	**1 985** [2.7]
	➢ School or Crèche	**580** [6.2]	**4 841** [7.7]	**5 421** [7.5]
	➢ Public Place	**592** [6.3]	**4 040** [6.4]	**4 632** [6.4]
	➢ Sport	**80** [0.9]	**453** [0.7]	**533** [0.7]
	➢ Other	**495** [5.3]	**3 006** [4.8]	**3 501** [4.8]
	➢ Unknown	**329** [3.5]	**2 531** [4.0]	**2 860** [4.0]
Median Child Dependency Ratio*****		**37.9** [IQR: 31.8; 41.9]	**38.9** [IQR: 33.9; 42.3]	**38.9** [IQR: 33.5; 42.3]
Kilometres from suburb of residence to RCWMCH******		[Row %]	[Row %]	[Col %]
	➢ >30 KM	**44 [3.9]**	**1 090 [96.1]**	**1 134 [1.6]**
	➢ 20-30 KM	**293 [5.2]**	**5 319 [94.8]**	**5 612 [8.1]**
	➢ 10-20 KM	**2 468 [9.5]**	**23 403 [90.5]**	**25 871 [37.3]**
	➢ 0-10 KM	**6 259 [17.1]**	**30 458 [83.0]**	**36 717 [53.0]**

#Primary Health Care ##Intensive Care Unit

**Study enrolment ended in June 2013 (6 month shorter period than other categories)*

***Data on first injury only. Only top five causes are presented. Further causes are presented in Appendix F Table 3*

****Patients demising at initial presentation excluded from the study*

*****The eight geographic Health Sub-Districts of the City of Cape Town*

******Child Dependency Ratio calculated from South African Census Data 2011 [(Total n children (0-14years) in suburb) / (Total n adults (15-65years) in suburb)] x 100*

*******Kilometres calculated as distance from centre of suburb to Red Cross War Memorial Children's Hospital*

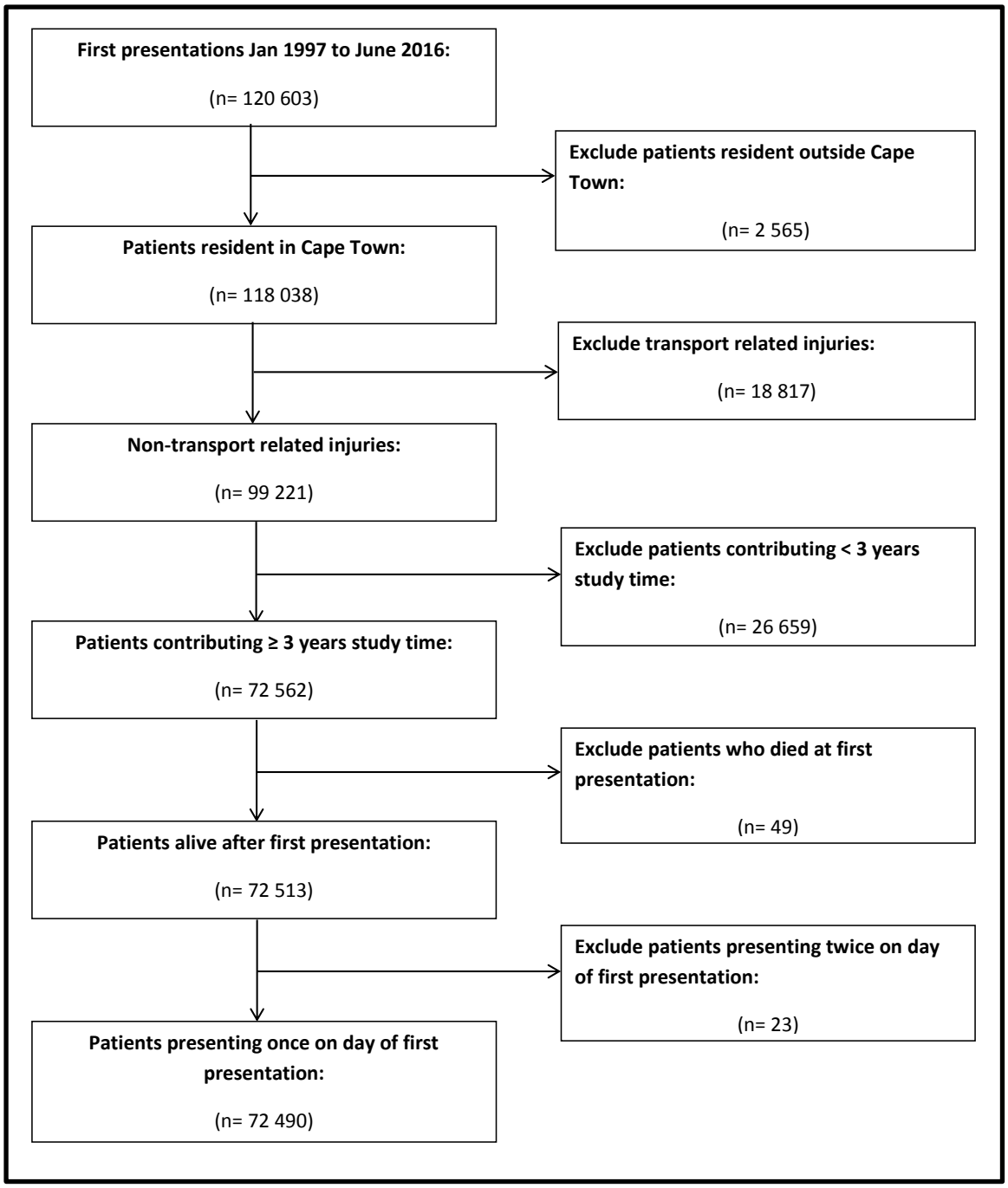

Figure 2: Study sample flow map

Table 2: Absolute and adjusted incidence rate ratios for repeat injury presentation to Red Cross War Memorial Children's Hospital Trauma Unit, for different child, injury and environmental characteristics from January 1997 to June 2016 using Poisson regression

	Variables	Crude Absolute Incidence Rates		Final Model		
Source		Absolute Incidence Rate per 100 person years	95% Confidence Interval	Adjusted Incidence Rate Ratio	P-Value	95% Confidence Interval
Demographics	**[Reference Age: <1 year]**			-	-	-
	Age in years at first presentation			0.9*	<0.001	[0.9; 0.9]
	[Reference: Female]	1.9	[1.8; 2.0]	-	-	-
	Male sex	2.6	[2.6; 2.7]	1.4	<0.001	[1.4; 1.5]
Injury by Cause**	All Other Aetiologies **[Reference]**			-	-	-
	Fall from non-height level	2.7	[2.6; 2.8]	1.1	0.001	[1.0; 1.1]
	Struck by or against	2.6	[2.4; 2.7]	1.0	0.451	[0.9; 1.0]
	Fall from height level	2.5	[2.3; 2.6]	1.0	0.529	[0.9; 1.1]
	Foreign body ingestion	1.8	[1.7; 1.9]	0.7	<0.001	[0.7; 0.8]
	Fluid burn	1.1	[1.0; 1.2]	0.6	<0.001	[0.6; 0.7]
Injury by Intent	Unintentional **[Reference]**			-	-	-
	Self-Infliction	2.2	[2.0; 2.4]	1.0	0.253	[0.9; 1.0]
	Abuse	1.6	[1.5; 1.8]	0.6	<0.001	[0.4; 0.7]
Injury by Severity	Minor **[Reference]**	2.6	[2.6; 2.7]	-	-	-
	Moderate	1.8	[1.8; 1.9]	0.9	<0.001	[0.8; 0.9]
	Severe	1.2	[1.0; 1.5]	0.7	<0.001	[0.6; 0.8]
Discharge or transfer location	Home **[Reference]**	2.6	[2.6; 2.7]	-	-	-
	Absconded	2.1	[1.5; 2.9]	0.8	0.228	[0.6; 1.1]
	PHC# Clinic	2.4	[2.2; 2.7]	1.0	0.463	[0.9; 1.1]
	Other Hospital	1.7	[1.2; 2.3]	0.8	0.070	[0.6; 1.0]
	RCWMCH Out-Patients	2.2	[2.1; 2.2]	0.9	0.001	[0.9; 1.0]
	RCWMCH Ward	1.5	[1.3; 1.8]	0.7	<0.001	[0.6; 0.9]
	RCWMCH Burns Unit	0.8	[0.7; 0.8]	0.5	<0.001	[0.5; 0.6]
	RCWMCH ICU##	2.3	[1.6; 3.2]	1.5	0.024	[1.1; 2.1]
	Childcare Agency	1.1	[0.4; 2.6]	0.6	0.266	[0.3; 1.5]
Health Sub-District***	Khayelitsha **[Reference]**	0.8	[0.7; 0.8]	-	-	-
	Eastern	0.7	[0.5; 0.9]	1.1	0.573	[0.8; 1.4]
	Northern	1.0	[0.8; 1.4]	1.8	<0.001	[1.3; 2.4]
	Tygerberg	2.1	[1.9; 2.2]	1.8	<0.001	[1.6; 2.1]
	Klipfontein	3.3	[3.2; 3.4]	2.4	<0.001	[2.1; 2.8]
	Southern	2.0	[1.9; 2.1]	2.0	<0.001	[1.7; 2.3]
	Western	2.9	[2.8; 3.1]	2.3	<0.001	[2.0; 2.7]
	Mitchells Plain	2.0	[1.9; 2.1]	2.4	<0.001	[2.1; 2.7]
	Unknown	2.7	[2.5; 3.0]	1.8	<0.001	[1.5; 2.2]
Place	School or Crèche **[Reference]**	2.1	[1.9; 2.2]	-	-	-
	Inside Own Home	2.4	[2.3; 2.4]	1.2	<0.001	[1.1; 1.3]
	Outside Own Home	2.3	[2.2; 2.4]	1.1	0.048	[1.0; 1.2]
	Inside Other Home	2.0	[1.8; 2.3]	1.1	0.450	[0.9; 1.2]
	Outside Other Home	2.2	[1.9; 2.4]	1.1	0.398	[0.9; 1.2]
	Road or Pavement	2.3	[2.1; 2.6]	1.1	0.229	[1.0; 1.3]
	Public Place	2.4	[2.3; 2.6]	1.1	0.023	[1.0; 1.3]
	Sport	3.5	[2.9; 4.2]	1.6	<0.001	[1.3; 2.0]
	Other	2.4	[2.3; 2.6]	1.2	0.013	[1.0; 1.3]
	Unknown	2.1	[1.9; 2.3]	1.1	0.326	[0.9; 1.2]
Child Dependency Ratio******	Low **[Reference]**	3.4	[3.3; 3.5]	-	-	-
	Medium	1.8	[1.8; 1.9]	0.9	0.007	[0.9; 1.0]
	High	2.2	[2.1; 2.3]	0.8	0.288	[0.5; 1.2]
Kilometres from suburb of residence to RCWMCH*******	> 30 KM **[Reference]**	0.7	[0.5; 0.9]	-	-	-
	20 – 30 KM	0.8	[0.7; 0.9]	2.4	<0.001	[1.7; 3.2]
	10 – 20 KM	1.6	[1.6; 1.7]	2.4	<0.001	[1.8; 3.1]
	0 – 10 KM	3.1	[3.0; 3.2]	3.8	<0.001	[2.9; 4.9]

#Primary Health Care ##Intensive Care Unit

*Refers to adjusted incidence rate ratio, per year increase in age

***Data on first injury only. Only top five causes are presented. Further causes are presented in Appendix F Table 3*

****The eight geographic Health Sub-Districts of the City of Cape Town*

*****Child Dependency Ratio calculated from South African Census Data 2011 [(Total n children (0-14years) in suburb) / (Total n adults (15-65years) in suburb)] x 100*

******Kilometres calculated as distance from centre of suburb to Red Cross War Memorial Children's Hospital*

Geospatial Factors

First presentation injury aetiology differed by Sub-District, with fluid burn injuries predominating in Northern, Eastern and Tygerberg Sub-Districts, and fall injuries predominating in Southern, Western, Mitchells Plain, Khayelitsha and Klipfontein (Figure 3).

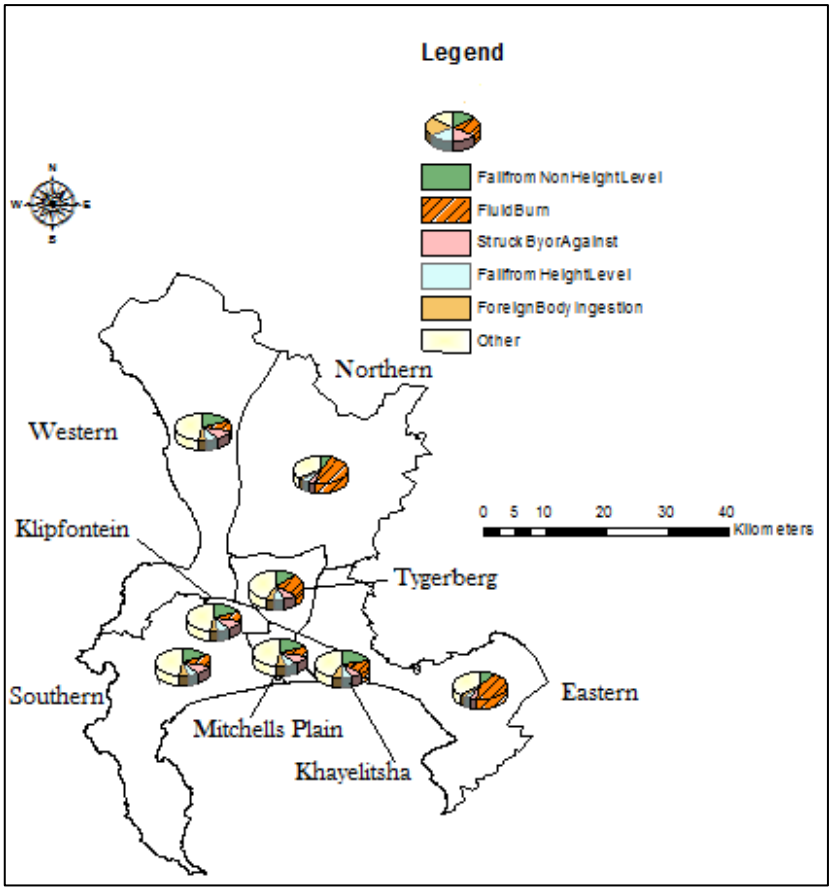

Figure 3: Injury aetiology at first presentation by health Sub-District

Patients residing closest to RCWMCH TU recorded higher rates of repeat presentation, with aIRR of 3.8 (95%CI:2.9 – 4.9) for patients residing <10km vs >30 km away; p<0.001. The eight health Sub-Districts in the Cape Town Metropole displayed differing rates of repeat presentation, even when adjusting for proximity to RCWMCH TU. Klipfontein Sub-District, in which the TU is located, recorded the highest rate of repeat presentations, at 3.3 (95%CI:3.2 – 3.4) per 100 py.

The Khayelitsha and Eastern Sub-Districts, the centre points of which are located furthest from RCWMCH TU, recorded the lowest rates, at 0.8 (95%CI:0.7 – 0.8) and 0.7 (95%CI:0.5 – 0.9) per 100 py respectively. However, these patients may have been more likely to present to other facilities within their referral zones for their repeat presentations.

When adjusting for all other variables including distance from facility, Klipfontein patients demonstrated the highest aIRR for repeat presentation, at 2.4 (95%CI:2.1 – 2.8; p<0.001). Local place of first injury was similar for both single and repeat presenters – with over half of all injuries occurring within one's own home, approximately 20% occurring outside one's own home, and approximately 7% at a school or crèche.

Children resident further away from RCWMCH TU tended to have more serious injuries, in keeping with the facility's status as a tertiary level trauma unit. This relationship was similar for both single and repeat presenters; however patients who repeat presented tended to reside closer to RCWMCH TU than single presenters across all injury severity categories (Figure 4).

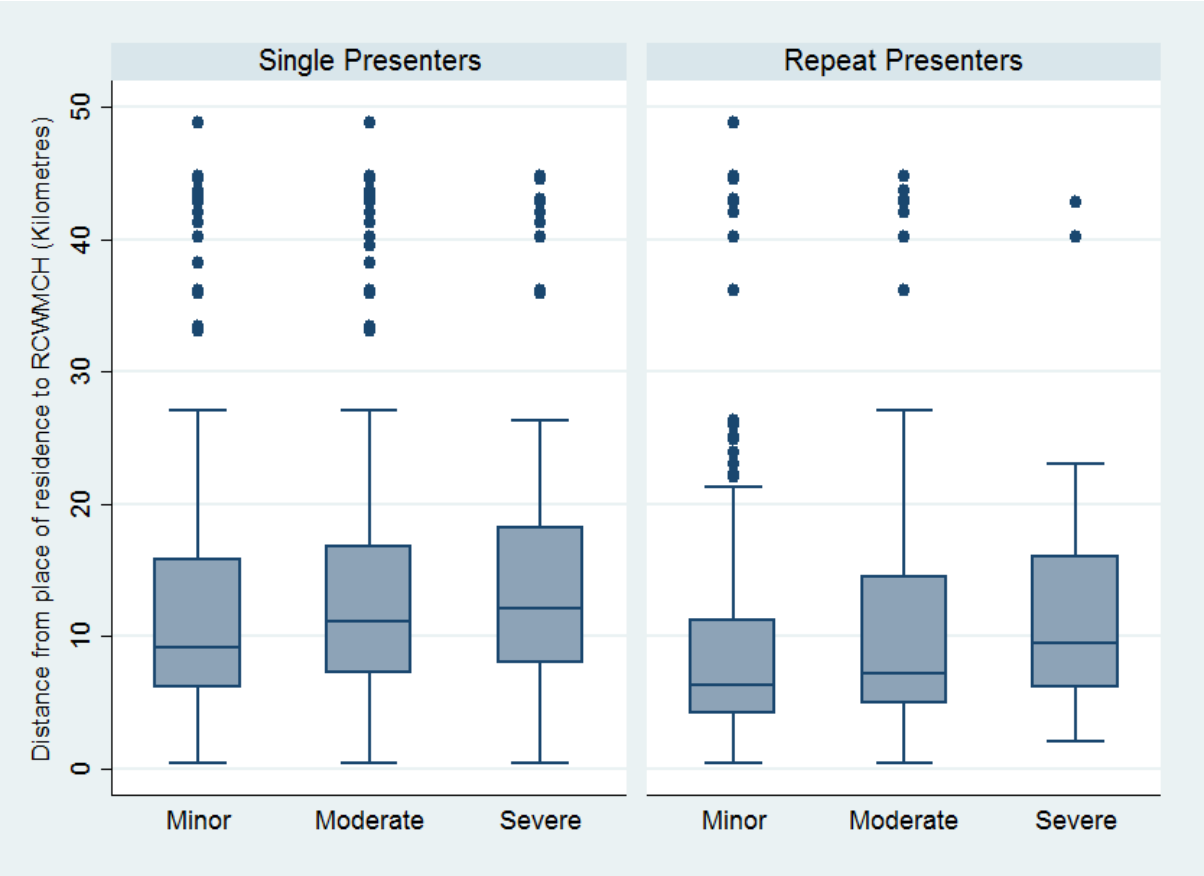

Figure 4: Box Plot of Residential Distance from RCWMCH by severity of first injury, for Single and Repeat Presenters

Discussion

This study demonstrated a substantial burden of repeat childhood injury at the RCWMCH TU. These results concur with RIC meta-analyses which showed that within cohorts of injury victims are "a sub-group of patients at increased risk for repeat injuries, such that they present with greater frequency than that which would be expected due to chance alone."[8]

In keeping with previous studies and global reports, males were significantly more likely to re-present to the trauma unit than females.[1] Understandably, patients who presented multiple times were more likely to have a first presentation earlier in life. This may suggest a 'riskier' environment – with a preponderance of frequent and earlier injuries in certain individuals and communities. Although patients first presenting earlier in life would have had more time to re-present, this was controlled for in the Poisson regression analysis.

The variable most strongly associated with repeat presentation was residence within a 10 kilometre radius of RCWMCH TU. Controlling for all other variables, these patients repeat presented at 3.8 (95%CI:2.9 – 4.9) times the rate of those living further than 30 kilometres away ($p<0.001$). Patients from areas further away from RCWMCH tended to have more severe injuries, in keeping with the fact that the TU is a tertiary referral unit. Although patients with severe injuries had lower rates of repeat injuries, there may be an element of confounding between distance and severity, with patients with severe injuries from further away presenting to local area clinics in the event of minor repeat injuries. Since this analysis was based on presentation to RCWMCH TU, rather than actual injury occurrence, caregiver health seeking behaviour may also affect the validity of the inference that minor injuries are related to repeat injuries. – caregivers who bring children to hospital for a first minor injury may be more likely to bring children to hospital in general, whereas those that only present when an injury is severe may be less likely to seek healthcare for injuries in general.

Percentages for repeat presentation differed substantially across health Sub-Districts across the Cape Town Metropolitan area. Sub-Districts closer to RCWMCH such as Klipfontein and Western recorded higher percentages of repeat presentation, possibly due to geographic referral zones in the Metropole. When controlling for all other variables including distance from facility, injury victims from Klipfontein remained most likely to repeat present.

In the adjusted analysis, patients with falls from non-height level injuries at first presentation were most likely to have repeat presentations. Fall-type injuries predominated overall, with more than 25% of first-time injuries being due to falls from either height or non-height levels. Those suffering fluid burn injuries were significantly *less* likely to have a repeat injury. Burn injuries tend to require long admissions, with multiple opportunities for burn prevention education. Childsafe also conducts injury prevention training sessions upon discharge, which includes specific interventions to prevent household fires.[7] The finding that burn injuries are unlikely to repeat may be interpreted two ways; RCWMCH's post-discharge burn prevention education is either highly effective, or not needed – this requires further exploration.

The finding of an inverse relationship between definitive cases of abuse and RIC should be interpreted within the context of South African legislation – all healthcare practitioners

suspicious of non-accidental injury in children are obligated to report suspected abuse to relevant authorities. An inverse relationship thus suggests that recognition of abuse by healthcare professionals may mitigate recurrence thereof.

Repeat presentations were associated with lower injury severity. Major injury is likely to have a large psychological impact on patients and caregivers, who may then be more likely to implement injury prevention measures at home and those with severe injuries are more likely to be exposed to injury prevention education and counselling from facility healthcare practitioners. However, patients experiencing major injury may also be more likely to belong to communities in which health-seeking behaviour is poor – and may actually experience multiple subsequent injuries, without presenting for hospital care. Finally, in order to ensure that all patients had at least 3 years of person-time while "at risk" of a second injury presentation, we excluded children who died within 3 years of their first presentation. Children with more severe injuries would be more likely to die after first presentation and so while their exclusion was necessary, this may have affected our findings about the relationship between injury severity and repeat presentation.

In the adjusted analysis, patients who were discharged directly home were at greatest risk for repeat injury, except for those admitted to ICU with an aIRR of 1.5 (95%CI:1.1 – 2.1; p=0.024). Unfortunately, the analysis was unable to include clinically relevant information such as permanent co-morbidity after first presentation, which is understood from the literature to be a significant risk factor for repeat injury; including injury sequelae such as permanent musculo-skeletal or neurocognitive disabilities which predispose children to subsequent (especially fall-related) injuries in future.[13] Although most repeat injuries occurred within patient's own homes, the place category with the greatest risk of repeat presentation was Sport, with an aIRR of 1.6 (95%CI:1.3 – 2.0; p<0.001). Although this represents a relatively small number of patients (n=533), this is an important area for injury prevention education at first presentation for healthcare.

CDR proved to be unhelpful in differentiating areas prone to repeat presentations. An important limitation of this unweighted variable was the use of results from a single census (2011), whereas the study spans a 20 year period with much population fluctuation, over which period living conditions and demographics were likely to have changed. An extended period of time was selected for this study, so as to include the entire extent of individual's childhoods, which was up to 13 years of follow-up data for individuals who may have presented early in childhood. Twenty years of data allows for further sub-analyses, focusing on differential injury repeat rates between consecutive time periods within the study period.

The comparison of repeat injury rates across the entire Cape Metropolitan area was hampered by use of single facility data. This likely led to an undercounting of RIC, which may have affected certain levels of injury severity more than others. Although RCWMCH has the only dedicated children's trauma unit in the City, most injuries and repeat injuries were minor in nature. Patients residing further away may have presented appropriately for minor injuries according to referral zone at the nearest primary care facility or district hospital, or not at all.

Within the study period, referral practices may have changed over time, with new PHC facilities opening across the City, and new district hospitals opening in both Khayelitsha and Mitchell's Plain in the last five years of the study period, resulting in changes to formal referral pathways. Patients may also have been lost to follow up due to death or emigration outside of the Western Cape, which is not tracked by the Province.

This retrospective study was unable to directly measure pertinent patient or household-level information such as patient co-morbidity, quality of caregiver supervision, family size or structure. The use of census-level data from a single year to make assumptions regarding the family context of children presenting to the trauma unit may have introduced an element of ecological fallacy, with high CDR households presenting from low CDR areas. Census areas are also likely to have changed over time due to dynamic suburb borders. Attempt was made to rule out follow-up presentations for the same injury, but this is reliant on the accuracy of 'time since injury' data entry, and ultimately on patient or caregiver self-reporting. Finally, patients with poisoning could not be included in this analysis, as these patients are not assessed at the RCWMCH TU.

The results of this study demonstrate the specific host, agent and environmental factors relevant in determining risk for repeat injuries in children. Healthcare practitioners are thus well placed to identify patients at greater risk of repeat injury and institute appropriate pre-discharge health promotion. Our findings suggests that post-injury health promotion activities should not exclude patients who present with minor injuries, and that targeted education is indicated for specific injuries, including those due to non-height falls and injuries sustained whilst playing sport. Areas with high rates of repeat injuries require further community-based research to determine specific household factors which predispose children to repeat injury.

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No funding was sought or received in order to carry out this research.

We declare no conflict of interest in the publishing of this article.

Part D: Appendices

Tables, Figures & Legends

Appendix A: Ethics Approval Letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 404 7682 • **Facsimile** [021] 406 6411
Email: nosi.tsama@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

28 July 2017

HREC REF: 343/2017

Prof MA Davies
Public Health & Family Medicine
Entrance 5, level 5
Falmouth Building

Dear Prof Davies

PROJECT TITLE: "INJURY-PRONE AREAS" REPEAT PRESENTATIONS FOR INJURIES IN CHILDHOOD (Masters' candidate-Dr S Peters)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30th July 2018.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

We acknowledge that the student Dr S Peters will be involved in this study.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval before the research may occur.

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Yours sincerely

pp TBurgess

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

Appendix B: Data Request Form (ChildSafe)

UNIVERSITY OF CAPE TOWN

H. Rode
Charles FM Saint Professor & Head of Department
A.J.W. Millar
Professor & Principal Specialist
Head: Transplantation
A.B. van As
Senior Lecturer & Head: Trauma Unit
A. Numanoglu
Senior Lecturer
L. Jee
Senior. Lecturer & Head: Urology
R.A. Brown
Honorary Senior Lecturer
S. Cywes
Emeritus Professor

DIVISION: PAEDIATRIC SURGERY
SCHOOL OF CHILD & ADOLESCENT HEALTH
RED CROSS WAR MEMORIAL CHILDREN'S HOSPITAL
RONDEBOSCH 7701
SOUTH AFRICA
TEL: +27 21 658-5012
Fax: +27 21 685- 66 32
Sebastian.vanas@uct.ac.za

Re: Legal undertaking regarding confidentiality

I SHRIKANT PETERS (full-names) of UCT (institution) hereby declare that I will practice absolute confidentiality with the research regarding non-accidental injured children at the Red Cross Children's Hospital. This data will be used for "Repeat Household Admissions for Unintentional Injury (M.Med) (purpose/aim of the study)

I further declare that I will at no time provide anybody outside the hospital with any information collected from our research.

I am fully aware that the medical information we will work with is extremely sensitive and that any misuse of information will lead to immediate expulsion from the hospital and termination of our research project and is likely to have medico-legal consequences.

We further agree to ackowledge Childsafe / Child Accident Prevention Foundation of Southern Africa as a source of this data and make a copy of the study or summary report available to Childsafe / CAPFSA by 01/09/17 (date).

SPeters (Signature) Date 20/03/2017

SHRIKANT PETERS (Name in full) ID / Passport 8703115162084

Address & Contact details 083 799 5263
Flat 217, Portofino, The Island Club, Rialto Rd
Century City, 7441

childsafe
KEEP KIDS FREE FROM HARM

A Member Of Safe Kids WORLDWIDE

Appendix C: Data Request (Western Cape Provincial Health Data Centre)

Annexure A

APPLICATION FOR ACCESS TO HEALTH DATASETS

The following application form is to be completed by all person/persons/organisations/groups who wish to access to health-related datasets from Western Cape Department of Health and is to be completed in accordance with the Departments' *Guidelines on requests for access to patient datasets from the Department of Health*. Please note that application for use of data does not guarantee that the data request will be approved. If the intended purpose for data access is altered or extended in anyway, a new agreement must be entered into.

Applicant details: *(Refers to the detail of the person requesting the change.)*

Name:	**Shrikant**	**Surname:**	**Peters**
Designation / Rank:	**Public Health Registrar**	**Date:**	17/10/2017
Organisation:	Western Cape Department of Health		
Email:	Shrikant.Peters@westerncape.gov.za	**Tel/Cell:**	083 799 5263

Please supply the contact detail of the person to whom the processed application must be returned.

Details of Data Request: (please append any additional information where necessary)

Type of Data Requested : (please tick appropriate option)	Aggregated data	Non-identified individualised data	Identified individualised data √
Please provide a short description of the data requested. Please attach a list/attach a list of the variables required. I require access to the following patient and mortality data held by the Provincial Health Data Centre: - Folder Number | PHDC Study Patient Dominant ID | Facility ID | Data Source | Date of Death | Cause of Death This would include mortality data from all facilities in the province, at all ages of death.			
Do you have a National Health Research Database ref no.?		Yes √ No	Number: WC_201708_007
Time period the data should cover:		Start date: 01/01/1997	End date: 31/12/2016
Frequency of Access: (please tick appropriate option)		Once-off √	Periodically
If periodically, please specify time frames for access: N/A			
Is the data to be used for research purposes?		Yes √	No
Please provide a brief motivation for this request, highlighting the purpose for which the data will be used I require access to patient and mortality data for a cohort of patients who attended the Red Cross Hospital Trauma Unit, from the 1st of January 1997, to the 31st of December 2016. I have attached a spreadsheet of the relevant folder numbers. An integral part of this study is the linkage of repeat trauma data to mortality data, to generate patient-time in study, and calculate Incidence Rate Ratios for repeat injury presentations. **Study not funded/funded by: N/A – No funding required**			
Do you have a security protocol for handling the data (attach detail if necessary)?		Yes √	No

PHDC Manager- Technical assessment and comments: All good.		☑ Feasible *Where relevant:* ☑ Protocol cover ☑ Ethics → ✓ □ Consent docs waiver
Assigned PHDC analyst: Neobert	**PHDC Manager Signature:**	**Date:** 20/10/2017

Outcome of Application: (To be completed by the Designated Health Authority)

Name:	ANTHONY HAWKRIDGE	**Surname:**	HAWKRIDGE
Designation / Rank:	DIRECTOR	**Signed:**	AT HAWKRIDGE.
Application Approved:	Yes / No	**Date:**	OCT 2017

5th Floor, 8 Riebeek Street, Cape Town, 8001, PO Box 2060, Cape Town, 8000
Tel: +27 21 483 9366 fax: +27 21 483 6058

TERMS OF AGREEMENT FOR ACCESS TO HEALTH DATASETS

The Western Cape Department of Health is committed to ensuring availability of data that supports the provision of health care and other essential services to authorised Users. This agreement aims to ensure the authorisation, maintenance of confidentiality and appropriate use of datasets provided to Users.

This agreement is between:
The Western Cape Government: Department of Health, hereafter "the Department"
AND

.....Shrikant Maurice Peters....., hereafter "the User"

1. Application for use of data must be made through the channels identified in the "*Guidelines on requests for access to patient data and patient information systems*" document.
2. This agreement sets forth the terms and conditions to which the Department will disclose certain confidential health information in the form of a Dataset(s).
3. The User agrees that the Department is the owner of the Dataset(s).
4. Permitted Uses and Disclosures:

4.1. Except as otherwise specified herein, the User may make all uses and disclosures of the ***Patient and Mortality*** Dataset(s) necessary to conduct the ***Research Study "Injury Prone Areas" – Repeat Injuries in Childhood*** for the period starting *(insert date User will receive Dataset(s))* and ending *(insert date agreement expires)*.

4.2. The User will receive the Dataset(s) **once-off**, from the designated Department official.

4.3. In addition to the User, the individuals, or classes of individuals, who are permitted to use or receive the Dataset(s) for purposes of the Identified Project include: ***Professor Mary-Ann Davies (Study Supervisor – University of Cape Town, School of Public Health)***

5. User Responsibilities:

5.1. The User will not use or disclose the Dataset(s) for any purpose other than permitted by this Agreement pertaining to the ***Research Study "Injury Prone Areas" – Repeat Injuries in Childhood*** for which written approval was granted.

5.2. The User agrees that the Dataset(s) provided will not be released to any third party that is not included by the provisions of the agreement between the primary parties, without the written permission of the Department. A third party will be required to complete an agreement as well.

5.3. The User agrees that the Department will be provided with an opportunity to comment and give feedback prior to the finalisation of any report/publication derived from the Dataset(s) according to the following conditions:

5.3.1. The data will be used to compile ***Repeat Injuries in Childhood (Report)*** for ***Western Cape Government Department of Health***

5.3.2. The report will be sent to the Department for perusal prior to finalisation. The latter should respond or react within 31 working days on the report being issued. If this period lapses it will be interpreted as a confirmation that the Department acknowledges the presentation and interpretation of data as correct and factual in the report.

5.4. The User will ensure that the Department is acknowledged in any output resulting from the use of the data including.

5.5. The User will communicate any data quality issues identified to the Department, to improve the dataset.

5.6. The User agrees that any use of the Dataset(s) or reliance by the User on any of the Dataset(s) is at the User's own risk and that Department shall not be held liable for any loss or damage howsoever arising as a result of such use.

5.7. The User agrees that he/she will make no statement nor permit others to make statements indicating or suggesting that interpretations/views drawn from the findings are those of the Department.

5.8. The User agrees that he/she will maintain confidentiality in accordance with item 6. Below.

6. Data Security and Confidentiality:

All Dataset(s) from the Western Cape Department of Health are to be treated as confidential and used in accordance with the following security standards:

6.1. Database storage: At a minimum the database must have user-level security, may not be housed on laptops or external media unless these are encrypted. Ideally the data should be stored on a central server with restricted access and not be stored on portable computer equipment like memory sticks, external hard drives and laptops.

6.2. The Data Sets(s) must be password protected and such passwords are not to be shared with anyone other than the principle user.

6.3. Data may not be linked to personally identifiable records from any other source unless prior approval has been explicitly granted.

6.4. File storage: At a minimum files will be stored with AES encryption e.g. 7-zip, and 15 character passwords which include numbers, special characters and letters.

6.5. Passwords and files may not be provided together but using two different methods of communication e.g. data zipped and e-mailed while password is SMS'ed to User.

6.6. When the timeframe for the agreed utilisation of the data expires (see item 4.1. above) the data must be destroyed in all its forms.

7. In making information available, the Department of Health reserves the right to set conditions in which its staff (including academic staff in joint provincial posts) should be invited to participate in any research undertaken that uses the data they have generated with a view to co-authorship of the final report/s.

8. The User accepts that this data is routinely collected as part of service delivery and therefore the data quality may not be of the highest quality.

9. Failure to adhere to the written agreement can and may be sanctioned

Signatories:

Shrikant Maurice Peters		**17/10/2017**
User's Name (Print)	Signature	Date
ANTHONY HAWKRIDGE	AT Hawkridge	23 OCTOBER 2017
Department of Health (Designated authority)	Signature	Date

3

Appendix D: SAMJ Guidelines

South African Medical Journal

Author Guidelines

COPYRIGHT
Material submitted for publication in the South African Medical Journal (SAMJ) is accepted provided it has not been published elsewhere. The SAMJ reserves copyright of the material published.

The SAMJ does not hold itself responsible for statements made by the authors.

CONFLICT OF INTEREST
Authors must declare all sources of support for the research and any association with the product or subject that may constitute conflict of interest.

PROTECTION OF PATIENT'S RIGHTS TO PRIVACY
Identifying information should not be published in written descriptions, photographs, and pedigrees unless the information is essential for scientific purposes and the patient (or parent or guardian) gives informed written consent for publication. Informed consent for this purpose requires that the patient be shown the manuscript to be published. (www.icmje.org)

ETHNIC CLASSIFICATION
Work that is based on or contains reference to ethnic classification must indicate the rationale for this.

MANUSCRIPTS
Short items are more likely to appeal to our readers and therefore to be accepted for publication.

Original articles of 3 000 words or less, with up to 6 tables or illustrations, should normally report observations or research of relevance to clinical medicine. References should preferably be limited to no more than 15.

The student project should be no more than 5000 words long. There is no limit to the references that may be listed.

MANUSCRIPT PREPARATION
Research articles should have a structured abstract not exceeding 250 words comprising: Objectives, Design, Setting, Subjects, Outcome measures, Results and Conclusions.

Refer to articles in recent issues for guidance on the presentation of headings and subheadings.

Abbreviations should be spelt out when first used in the text and thereafter used consistently.

Scientific measurements should be expressed in SI units except: blood pressure should be given in mmHg and haemoglobin values in g/dl.

Arrangement of papers

The structure of your report which will resemble the structure required for publication is as follows:

1. title page
2. abstract
3. introduction
4. methods
5. results
6. discussion
7. references
8. acknowledgements
9. tables
10. figures and legends

1. Title page

the title page should be as informative as possible, but should not exceed 150 characters and spaces. Three key words for use in the review process should be provided. The total number of words in the paper, excluding references and figure legends, should be added to the title page. The title page should include a list of the group members as well as the name of the supervisor separately.

2. Abstract

Research articles should have a structured abstract not exceeding 250 words comprising: Objectives, Design, Setting, Subjects, Outcome measures, Results and Conclusions.
Refer to articles in recent issues for guidance on the presentation of headings and subheadings.

3. Introduction and literature review

The introduction should make the background and the object of the research clear. Students should also include a section on the literature review. This section is similar, but should be an expanded version of what had been included in the original protocol.

4. Methods

Methods should be described once only.Start the methods section with a paragraph entitled ethics approval. Details of the ethical approval process should be included here.

5. Results

Students' results are presented here with some discussion as to the statistical processes used. These may be presented in table or other graphical representations.

6. Discussion

The discussion makes sense of the results section. It needs to be the analysis section of what was observed in the results. Do not rehash the results in this section.

7. References

See the section on references below

8. Acknowledgements

These need to be brief and follow rules of general courtesy.

9. Tables

10. Figures and legends

The above two may be used. Students are advised to ensure that their tables are clearly labeled with legends that allow their easy interpretation.

ILLUSTRATIONS

Figures consist of all material that cannot be set in type, such as photographs and line drawings. If any tables or illustrations submitted have been published elsewhere, the author should obtain written consent to republication from the copyright holder and the author(s). All illustrations, figures etc. must be of high resolution/quality, preferably jpeg or equivalent but not powerpoint, and preferably attached as supplementary files.

REFERENCES

References should be inserted in the text as superior numbers and should be listed at the end of the article in numerical and not in alphabetical order.

Authors are responsible for verification of references from the original sources.

References should be set out in the Vancouver style and approved abbreviations of journal titles used; consult the List of Journals in Index Medicus for these details.

Names and initials of all authors should be given unless there are more than six, in which case the first three names should be given followed by et al. First and last page numbers should be given.

Journal references should appear thus:

Price NC . Importance of asking about glaucoma. BMJ 1983; 286: 349-350.

Book references should be set out as follows:

Jeffcoate N. Principles of Gynaecology. 4th ed. London: Butterworth, 1975: 96-101.

Weinstein L, Swartz MN. Pathogenic properties of invading microorganisms. In: Sodeman WA jun, Sodeman WA, eds. Pathologic Physiology: Mechanisms of Disease. Philadelphia: WB Saunders, 1974: 457-472.

Manuscripts accepted but not yet published can be included as references followed by (in press).

Unpublished observations and personal communications may be cited in the text, but not in the reference list

Submission Preparation Checklist

As part of the submission process, authors are required to check off their submission's compliance with all of the following items, and submissions may be returned to authors that do not adhere to these guidelines.

The submission has not been previously published, nor is it before another journal for consideration (or an explanation has been provided in Comments to the Editor).

The submission file is in Microsoft Word or RTF document file format.

When available, the URLs to access references online are provided, including those for open access versions of the reference. The URLs are ready to click (e.g., http://pkp.sfu.ca).

The text is single-spaced; uses a 12-point font; employs italics, rather than underlining (except with URL addresses). Figures consist of all material that cannot be set in type, such as photographs and line drawings. If any tables or illustrations submitted have been published elsewhere, the author should obtain written consent to republication from the copyright holder and the author(s). All illustrations, figures etc. must be of high resolution/quality, preferably jpeg or equivalent but not powerpoint.

The text adheres to the stylistic and bibliographic requirements outlined in the Author Guidelines, which is found in About the Journal.

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The SAMJ reserves copyright of the material published.

Privacy Statement

The names and email addresses entered in this journal site will be used exclusively for the stated purposes of this journal and will not be made available for any other purpose or to any other party.

Appendix E: Additional figures from Exploratory Data Analysis

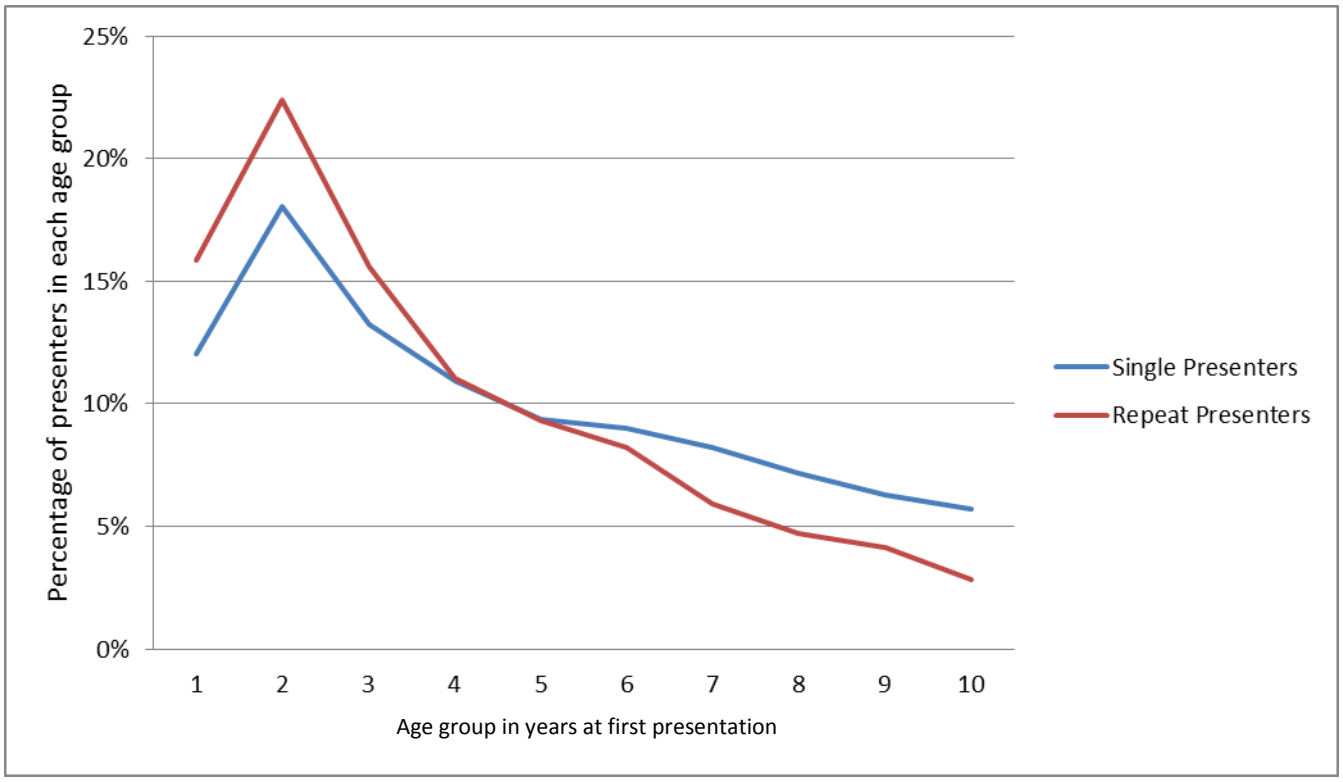

Figure 1: Age group in years at first presentation by single and repeat presenters

(X-axis represents upper limit in years of each age group, for e.g. age group=1: children presenting at 0 to <1 year of age)

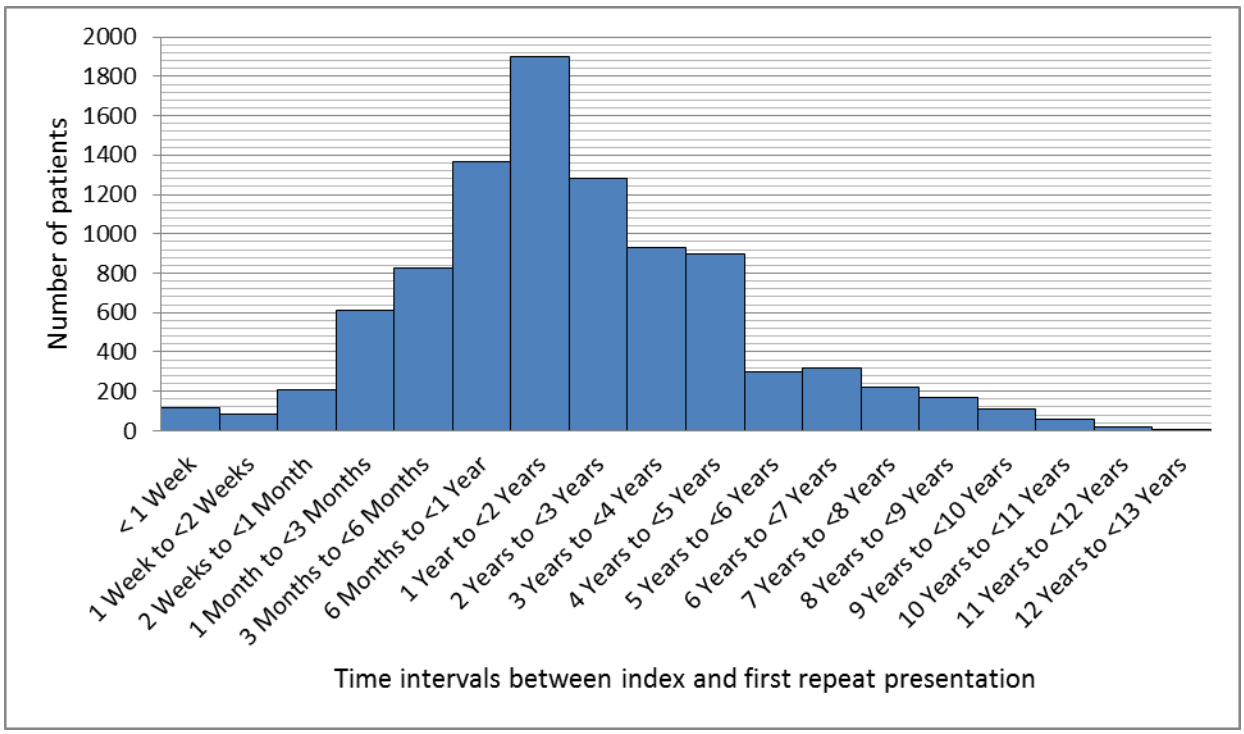

Figure 2: Number of patients with different time intervals between index and first repeat presentation

(Note that time intervals up to 1 year are shorter than subsequent time intervals which are all 1 year long)

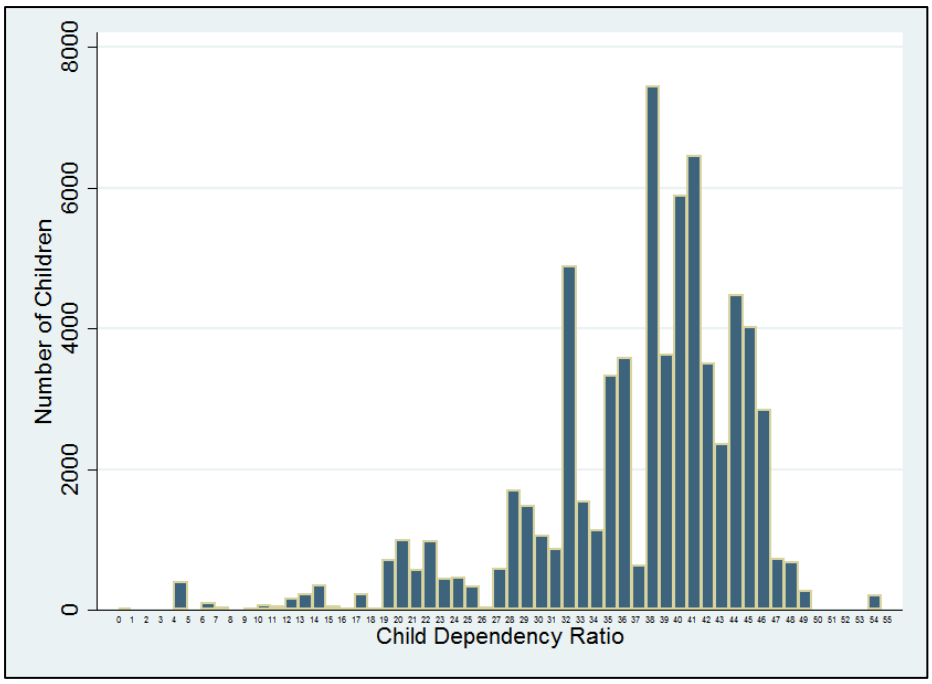

Figure 3: Number of children with different Child Dependency Ratios in Study Sample (N=72 490)

(Child Dependency Ratio calculated from SA Census 2011: [(Total number of children (0-14 years old) suburb)/ (Total number of adults (15-65 years old) suburb)] x100)

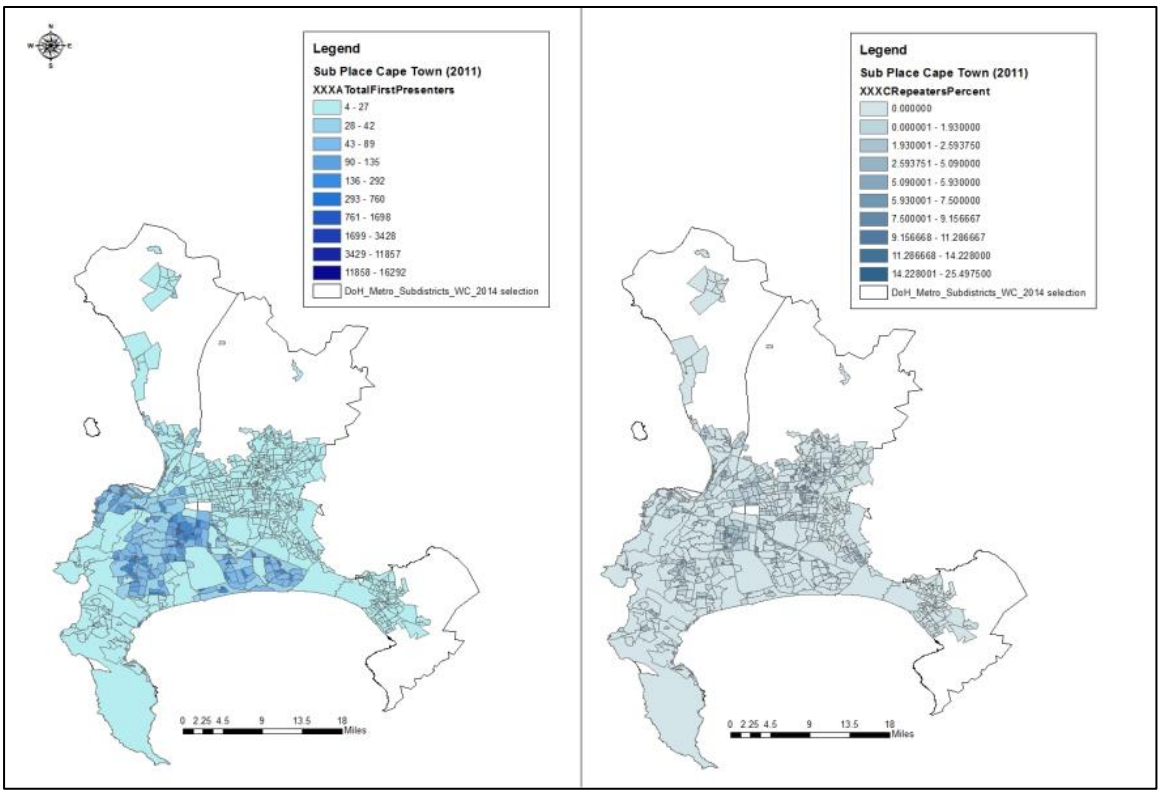

Figure 4: Heat map of first (left) and repeat (right) presentations by suburb of origin

Appendix F: Additional Tables from Exploratory Data Analysis

Table 1: Age in years at first presentation to Red Cross War Memorial Children's Hospital Trauma Unit for an injury in childhood

Age categories	Headcount	%
0 to <1 year	9074	12.5%
1 to <2 years	13499	18.6%
2 to <3 years	9826	13.6%
3 to <4 years	7934	10.9%
4 to <5 years	6767	9.3%
5 to <6 years	6451	8.9%
6 to <7 years	5756	7.9%
7 to <8 years	4960	6.8%
8 to <9 years	4364	6.0%
9 to <10 years	3859	5.3%
Grand Total	**72490**	

Table 2: Year of first presentation to Red Cross War Memorial Children's Hospital Trauma Unit for an injury in childhood

Year	Headcount	%
1997	4675	6.4%
1998	4000	5.5%
1999	4369	6.0%
2000	3936	5.4%
2001	3488	4.8%
2002	3882	5.4%
2003	4077	5.6%
2004	3956	5.5%
2005	4143	5.7%
2006	3830	5.3%
2007	4533	6.3%
2008	4397	6.1%
2009	5065	7.0%
2010	5304	7.3%
2011	5381	7.4%
2012	5047	7.0%
2013	2407	3.3%
Grand Total	**72490**	

Table 3: Top ten causes of injury for first presentation to Red Cross War Memorial Children's Hospital Trauma Unit (N=72 490)

Cause	Headcount	%
Fall from non-height level	13 888	19.2%
Fluid burn	7 926	10.9 %
Struck by or against	6 878	9.5%
Fall from height level	6 248	8.6%
Foreign body ingestion	4 917	6.8%
Fall off bed	4 425	6.1%
Other cause (not recorded)	4 339	6.0%
Fall from playground	4 191	5.8%
Unknown cause	2 704	3.7%
Caught between objects	2 674	3.7%

Table 4: Top ten causes of injury for second presentations to Red Cross War Memorial Children's Hospital Trauma Unit (Total n = 9 417)

Cause	Headcount	%
Fall from non-height level	2271	24.1%
Struck by or against	1238	13.1%
Fall from height level	892	9.5%
Fall from playground	711	7.6%
Other cause (not recorded)	683	7.3%
Foreign body ingestion	567	6.0%
Fall off bed	379	4.0%
Sharp instrument	361	3.8%
Caught between objects	327	3.5%
Fluid burn	311	3.3%

Table 5: Mortality and Incidence Risk in single and repeat presenters

	n	Mortality	Incidence Risk
Repeat Presenters	9 417	24	0.25 per 100
Single Presenters	63 073	53	0.08 per 100

Incidence Risk Ratio = [24/ (9417)] / [53/(63073)] = 3.03

Patients in the repeat presentation group had 3.03 times the risk of dying in the province within the study period, due to any cause, relative to patients with only single presentation.*Patients who died at or within 3 years of first presentation were excluded from the study, which would bias these results – which were thus removed from the main paper.

Table 6: Absolute incidence rates of repeat presentations to Red Cross War Memorial Hospital Trauma Unit from January 1997 to June 2016

Age in years at first presentation	Incidence Rate [Repeat Presentations/100 person-years]	95 % Confidence Interval
0 to <1 year	2.6	[2.5; 2.7]
1 to <2 years	2.5	[2.4; 2.6]
2 to <3 years	2.4	[2.2; 2.5]
3 to <4 years	2.1	[2.0; 2.2]
4 to <5 years	2.2	[2.1; 2.4]
5 to <6 years	2.2	[2.0; 2.3]
6 to <7 years	2.0	[1.8; 2.1]
7 to <8 years	2.0	[1.9; 2.2]
8 to <9 years	2.5	[2.2; 2.7]
9 to <10 years	2.4	[2.1; 2.6]